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COMPUTER-BASED INSTRUCTION FOR TRIDENT FBM TRAINING

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FOR TRIDENT FBM TRAINING

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FOREWORD

This study was conducted in support of a project order from the Strategic System Project Office, Training Plans Branch (SP-15), to determine the use of computer-based instruction for TRIDENT Strategic Weapons System training. The Navy Personnel Research and Development Center was assisted by the Naval Instructional Technology Development Center and Sensors, Data, Decisions, Incorporated.

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SUMMARY

Problem

Strategic Weapon System (SWS) laboratory training at the TRIDENT Training Facility will consist of tactical equipment combined with special stimulation hardware (non-tactical equipment) to provide a high fidelity training environment. Early in the planning, the decision was made to minimize the amount of expensive tactical/non-tactical laboratory equipment. By installing one laboratory unit each and supplementing the training with a less expensive form of instruction, the student loads in a laboratory can be reduced to a manageable size with considerable savings. Computer-based instruction (CBI), as an individualized, interactive form of instruction, was identified as a prime candidate to supplement the stimulated laboratory training.

Purpose

The objectives of this study were:

1. To develop the criteria and data on which to base a decision for organized CBI implementation.

2. To develop the criteria and data for selecting CBI hardware, software, and personnel.

3. To recommend procedures and roles for the implementation of CBI.

4. To recommend procedures and roles for the maintenance of CBI.

Approach

To meet the objectives of this study, it was necessary to determine the optimum life-cycle costs for CBI support of SWS laboratory training. Three phases to the process were defined. In Phase I a training analysis was performed to define the training objectives for a CBI system. The training analysis indicated the amount and types of training and the simulation characteristic requirements. The results of Phase I were then input to Phase II for an analysis of existing CBI systems. Personnel numbers, types, functions, roles, and procedures were determined for each CBI system which met the criteria developed in Phase I. Finally, in Phase III all of the elements for each CBI system candidate were costed over a 10-year life-cycle. These costs were compared for selection of the most cost-effective total configuration.

Results and Conclusions

Section 2 describes Phase I of the study: an analysis of TRIDENT SWS training to determine a CBI curriculum configuration which would reduce student loads in laboratory training. The major conclusions of Phase I were that:

1. SWS laboratories will be sufficiently overloaded to warrant a supplemental form of instruction.

2. CBI, as an interactive instructional form, can supplement laboratory training.

Section 3 describes Phase II of the study: the identification of alternative CBI system configurations to meet SWS training requirements and the definition of procedures for CBI configuration control and management. The major conclusions of Phase II were that:

1. Of the existing CBI systems, three systems, each representing a different type of configuration, can meet the laboratory training requirements.

2. The personnel configuration is a function of the CBI system configuration.

3. CBI configuration control and management procedures can be defined within the current training system documentation.

Section 4 describes Phase III: a comparative analysis of the costs of the three CBI system configurations, including hardware, curriculum material, and personnel, over a 10-year life-cycle. The major conclusions of Phase III were that:

1. One of the CBI system candidates could easily be identified as the most cost-effective configuration to meet TRIDENT SWS laboratory training requirements.

2. Conditions other than those defined in this study could change the comparative costs, however, and care must be taken in generalizing about the relative costs of the three systems.

3. Growth of CBI functions, beyond reducing laboratory overloads, should be investigated to achieve full benefits from the system.

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SECTION 1. INTRODUCTION

1.1 Problem

Strategic Weapon System (SWS) training at the TRIDENT Training Facility (TRITRAFAC) will be held both in classroom and laboratory settings. The SWS laboratories at TRITRAFAC will consist of tactical equipment combined with special stimulation hardware (nontactical equipment) to provide a high fidelity training environment. Early in the planning of TRITRAFAC, the decision was made to minimize the amount of expensive tactical/nontactical laboratory equipment. Rather than provide for all laboratory training by such a stimulated environment, means for supplementing the stimulation by less expensive forms of instruction were considered. The equipment for the laboratories in which computer-based instruction (CBI) is recommended cost $22,000,000. Cost of the CBI equipment is expected to be less than $650,000. By installing one laboratory unit each and supplementing the training with CBI to reduce student loads in the laboratory to a manageable size, considerable savings will be achieved.

It is in the overloaded laboratory situations where an alternative method of training was desired to achieve the high fidelity environment with minimum costs. Given the operational nature of laboratory training, CBI seemed to be a prime candidate as an alternative to more laboratories. CBI is an individualized, self-paced, and, even more important, an interactive instructional system. Furthermore, utilizing CBI associated media such as slides and graphics provides an outstanding capability for simulation. As a training simulation vehicle, CBI also appears to be economical. Fletcher (1975) noted that computer-based simulation, as a special use of CBI, promises major reductions in material preparation costs. Achievement gains reported by Suppes, Fletcher, and Zanotti (1973a, 1973b), Vonsonhaler and Bass (1972), and others, along with economic data reported by Ball and Jamison (1973), Butnam (1973), and Jamison, Fletcher, Suppes, and Atkinson (1974) argue favorable cost/benefits for CBI in the specific application under study here.

One final note is in order by way of definition. While the term "CBI" is used in this study, it was discovered that the "computer" aspect has become somewhat blurred as electronic technology advances to new states-of-the-art. Several of the CBI systems analyzed in Section 3 have "computer like" processors which bear little resemblance to an automatic data processing computer.

1.2 Objectives

Four objectives were set for the study. The purpose of each objective was to provide the managers of TRIDENT SWS training, SP-15, with sufficient information for decisions and plans on the use of CBI. Each objective represents a chronological decision point for SP-15. That is, determination must be made: (1) whether CBI can be used effectively for reducing

laboratory overloads, (2) if so, what requirements of CBI hardware, software, and personnel match the specific training needs, (3) what procedures and roles are most efficient for the Navy and contractor activities in design, implementation, and evaluation of CBI curriculum, and (4) what procedures and roles are most efficient for maintaining CBI materials given a new and changing curriculum. The objecitves of the study were, therefore:

a. develop the criteria and data on which to base a decision for organized CBI implementation,

b. develop the criteria and data for selecting CBI hardware, software, and personnel,

c. recommend procedures and roles for the implementation of CBI,

d. recommend procedures and roles for the maintenance of CBI.

1.3 Approach

The basic approach in meeting the above objectives was to determine the optimum life-cycle costs for CBI support of SWS laboratories. The optimum costing was to be derived by comparing costs of the alternative CBI systems and personnel over a 10-year period. This is the subject of Section 4. The life-cycle costing was accomplished by matching the CBI support requirements to the training system characteristics and costing each element, as seen in Figure 1-1.

Three phases of the process were defined. Each phase addressed some aspect of the configuration which would be necessary for CBI in SWS laboratory training. In this study, configuration is defined as all parts of the system, including machine and people, to meet the system objectives. In Phase I (Section 2) the configuration training analysis was performed to determine the training objectives of an SWS CBI system. The training analysis indicated the amount and type of training for CBI implementation which would reduce laboratory overloads. Additionally, it was possible to identify the CBI simulation characteristics required for these training topics.

The results of Phase I were then input to Phase II (Section 3) for an analysis of existing CBI systems. The analysis allowed determination of those CBI computer systems which could meet the needs of SWS laboratory training. Personnel numbers, types, functions, roles, and procedures could then also be determined for each of the CBI computer systems which met the criteria developed in Phase I.

Finally, in Phase III (Section 4) all of these system elements were costed over a 10-year life-cycle for each alternative CBI configuration. The costs were compared for selection of the most cost effective total configuration. It was not until completion of Phase III that the goals of the study were fulfilled because all final recommendations were based on costs.

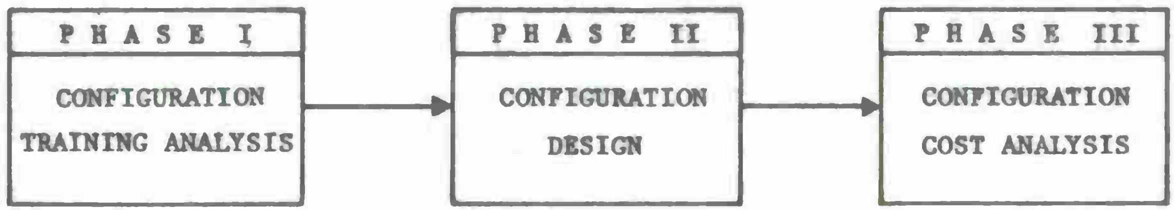

Figure 1-1. Major phases of study

SECTION 2. PHASE I: CONFIGURATION TRAINING ANALYSIS

2.1 Overview

Paragraphs 2.2 (FBM laboratory utilization) and 2.3 (CBI selection methodology) describe the initial two tasks necessary for the training analysis. First, it was necessary to determine whether or not there were sufficient overloads to warrant CBI and, if so, where in the training the overloads occurred. Second, it was necessary to derive a method for selecting the CBI amenable curriculum areas which could be developed to reduce overloaded laboratories.

Each of the three laboratories projected to have overloads at TRITRAFAC were then studied using the methodology described in paragraph 2.3. The method first selects specific equipment in a laboratory by ranking amenability to CBI. Each equipment is then described by training level, instructional objectives, and laboratory simulation requirements. This description allows a preliminary design of CBI strategies and suggested terminal media requirements. Two major results were, therefore, derived: (1) the selection of laboratory equipment and training to be simulated by CBI for the purpose of removing overloads, and (2) identification of possible CBI strategies and terminal requirements. The laboratories studied are the Launcher Control Group, the Fire Control System Unit, and the Missile Control Center. They are described in paragraphs 2.4, 2.5, and 2.6, respectively.

The interface between the student and a CBI system is an interactive terminal which presents instructional information and allows the student to respond. The CBI terminal is, therefore, a form of instructional media which should support the training requirements. Two aspects of the CBI terminals (i.e., characteristics and numbers required) are discussed in paragraphs 2.7 and 2.8. Thus, in Phase I, the analysis proceeds from specification of training tasks to specification of media, the CBI terminals.

2.2 FBM Laboratory Utilization

Laboratory utilization for SWS training was analyzed by two categories. First, each laboratory includes several types of training. Some training types seemed more amenable to CBI than others. Within each laboratory, the most CBI amenable training types were selected for more detailed analysis. Second, since each of the seven SWS laboratories operates and can be scheduled separately from the others, the student load projected for each laboratory was a utilization unit of measure. The result of this portion of the study is selection of CBI candidates by types of training within laboratories which will be overloaded.

The results were achieved by three steps and these are presented in the following pages in order. The first step was determination of training types as CBI candidates within the labs. The second step was determination of the projected laboratory loads and criteria for specifying an overload. The third and final step was determination of the number of CBI curriculum hours required to reduce the laboratory overloads to a manageable size.

It should be noted that full consideration was given to other means for reducing laboratory overloads. For instance, it did not appear cost-effective to install additional laboratory units for the relatively small amount of overloads expected. Also, scheduling of laboratories appears to be handled well currently in POSEIDON/POLARIS training sites and is expected to be at least as efficient for TRITRAFAC SWS training. Overloads are still expected and, as will be seen later in this section, are best handled by a media form which allows interactive, dynamic, real-time training. Only CBI has these characteristics.

2.2.1 SWS Training Types

Five types of training are provided in the SWS laboratories of concern: (a) replacement, (b) off-crew, (c) officer, (d) intermediate level maintenance, and (e) conversion. Each of these were examined to identify the most likely types for CBI implementation.

Certain types of training are more appropriate for CBI than others. Training tasks which require team member interaction or physical manipulation are less preferred CBI simulation candidates than those which are individual and knowledge oriented. Using this rationale, the replacement and limited portions of system crew training offered attractive topic areas for CBI applications while officer and second-level maintenance training appear less suitable. Conversion training does not appear to impinge on overloads in laboratories and was not considered for CBI candidacy.

a. Replacement Training

Replacement training provides new enlisted personnel with experience in TRIDENT systems and procedures. Trainees are qualified for a specific NEC at completion of replacement training. All personnel entering replacement training will be assigned to one of five courses in the operation and maintenance of the strategic weapons or navigation subsystems. Only training in system operation to the level of basic preventive and corrective maintenance procedures under supervision is given in these courses.

The best application of CBI resides in replacement training. Replacement laboratory training provides for learning skills which are both discrete, in that a unit piece of equipment can fulfill the focal point of the learning experience, and individual, in that there is

little need for operator interactions with others. The most extreme case requiring interaction is remote voice feedback to an operator. In this case it is possible to display text which represents the voice messages required during sequential operations on a particular piece of equipment. In addition, most other information flow to the replacement student, while operating a piece of equipment, is channeled by that equipment. Little is required beyond the recognition of illuminated actuator/indicators, switching positions, and digital and/or printer readouts. This equipment characteristic to channel information at the replacement training level aids in the determination of CBI implementation within TRIDENT laboratory training.

b. Off-Crew Training

Off-crew training is given to personnel who are already assigned to TRIDENT-I submarines while in port. TRITRAFAC will provide two types of off-crew training: advanced and team. Advanced courses are designed to increase operational and maintenance proficiency. A week of team training is provided for each crew, at the end of the off-crew period, to increase team proficiency. Neither type of training is recommended for CBI implementation with the purpose of reducing laboratory overloads.

(1) Advanced Training. Advanced training is given to senior NEC personnel in order to increase proficiency levels for performing normal and casualty operational procedures and also to provide fault isolation, major repairs, and emergency repairs without supervision.

Advanced training is better left to the laboratory because much of the curriculum deals with hands-on manipulation at the P2 and C3 levels. Training tasks such as wiretracing, attaching, and using test equipments are not well done without the hands-on experience. CBI displays, for more theoretical training, might have to be extensive enough to provide views from many angles and incorporate both actions and resultant displays with multiequipment usage. The interactive coordination between equipments, displays, operator actions, test equipment, and documentation might not be cost-effective. In addition, the advanced training level relies quite heavily on the maintenance documentation which drives P2 and C3 requirements. This documentation will change within the evolving TRIDENT submarine program and could cause explosive CBI courseware maintenance until it becomes more stable. For these reasons, it appeared that advanced training is not appropriate for CBI at this time.

(2) Team Training. Team training is focused at a system level in three areas: (a) skills and knowledge in the operation or maintenance of a particular piece of equipment, (b) use of documentation, and (c) team coordination between crew members. The latter is a major use of team training time. The implication of these three areas for CBI

implementation is possible application of CBI in the first two, but limited in the third. For the first area, CBI can, for example, provide some appropriate operation and maintenance team training in the LCG and FCSU laboratories and for some system-wide troubleshooting in the MCC laboratory. The objective associated with learning documentation during team training might also be accomplished by CBI. However, it appears that CBI could not adequately facilitate team development. Thus, CBI would be able to support a limited portion of the team training objectives.

c. Officer Training

Five types of officer training will be provided in the SWS portion of TRITRAFAC. The functions of each officer course package are given below (as taken from the TRIDENT-I Strategic Weapon System Navy Training Plan, 1 August 1975):

(1) PCO/PXO: Training familiarization and orientation for officers ordered as either Commanding Officer (CO) or Executive Officer (XO) of TRIDENT submarines. The training will provide overall system operation, capabilities, and performance criteria.

(2) STRATEGIC SYSTEM OFFICER: Training provides theory and overall system operation to permit supervision of those technicians assigned to operate and maintain the TRIDENT SWS.

(3) STRATEGIC MISSILE OFFICER: Training provides theory and knowledge of overall TRIDENT SWS operation and maintenance sufficient to permit supervision onboard a TRIDENT-I SSBN.

(4) STRATEGIC NAVIGATION OFFICER: Training provides theory and operation knowledge sufficient to permit supervision of technicians assigned to operate and maintain the TRIDENT Navigation System.

(5) INTERMEDIATE LEVEL MAINTENANCE OFFICER: Training provides knowledge of theory, maintenance, and operation sufficient to permit supervision of maintenance technicians at the TRIDENT Refit Facility (shore-based maintenance).

Officer training does not appear to be a high-payoff area for CBI, where the purpose is to reduce laboratory overloads, because the number of officers to be trained is relatively low compared to enlisted personnel. Because of the small number, however, CBI may be advantageous as part of the course packages for self-paced, individualized instruction. This topic is discussed further in section 4 under CBI System Growth. An additional factor in officer training is that some part will center around supervision of enlisted personnel. In the latter situation it may be advisable to provide concurrent laboratory training rather than CBI.

d. Intermediate Level Maintenance Training

Personnel in the intermediate level maintenance shops will be trained in the same laboratories as those supporting replacement training or by add-on courses. The add-on courses will provide training only in the operation and maintenance of intermediate level maintenance equipment or special maintenance procedures and they will be given at the shop site rather that at TRITRAFAC laboratories. However, some parts of intermediate level maintenance will be held in the replacement laboratories. Neither area was considered for CBI. Heavy emphasis has already been placed on CBI implementation of replacement training as the most likely area for reducing overloads.

e. Conversion Training

Conversion training consists of courses designed to provide experienced POLARIS/POSEIDON SWS personnel with proficiency in TRIDENT systems and procedures. The training of POLARIS/POSEIDON experienced personnel will be a major effort during the TRIDENT build-up period, but will be discontinued or minimal at steady state student loading. Therefore, it was not included in this study for CBI consideration.

2.2.2 Determination of Laboratory Overloads

Projections of TRITRAFAC FBM laboratory loads were generated by General Electric Ordnance Systems (GEOS), Pittsfield, Massachusetts. The TRIDENT Laboratory Determination Model (LDM), developed by GEOS, dated 29 August 1975, provided yearly estimates of training time up to steady state utilization. Attempts were also made by GEOS to project weekly loads but the effort was not completed in time for inclusion in this study. The importance of weekly projections is that the fluctuations of laboratory loads could be seen within a year. That is, the weekly utilization might range from 100% to 400%, even though a yearly estimate of 135% is projected. Completion of weekly or monthly projections should provide data on which to update the recommendations of this study.

2.2.2.1 Available Training Time

A total of 3,402 hours per year are available for training in each laboratory (assuming 52 weeks/year, 5 days/week with 17 holidays, 7 hours/shift, and 2 shifts/day). This represents an ideal yearly 100% utilization without constraints. However, in the real world, there are situations which preclude 100% utilization and reduce the number of available hours. These were taken into account by the LDM.

One such constraint is the yearly maintenance downtime that each laboratory will experience. Preventative and corrective maintenance time has been estimated by GEOS at 340 hours per year. The maintenance time required reduces the number of available laboratory hours to 3,062 per year.

A second consideration in the LDM was scheduling inefficiency. GEOS, after polling the Guided Missile Schools at Dam Neck and Charleston, projected an inefficiency due to scheduling problems of 17.5%. This reduced the number of available training hours, when coupled with the maintenance downtime, to 2,526 yearly hours available per laboratory.

When compared to the ideal 100% utilization level of 3,402 hours for two shifts, the resultant 2,526 training hours provides a 74.25% utilization factor for any particular laboratory. The elimination of 876 yearly training hours as suggested by GEOS represents a lost time which could never be redeemed. A greater look into this assertion is necessary to determine its validity in light of actual operations in existing POSEIDON training facilities and the implications for TRITRAFAC.

Within a training facility, actual training hours are not lost except in the case of unexpected maintenance downtime extending over long periods of time. Rescheduling can and usually does make up for short maintenance downtime and only represents inconvenience. Scheduled preventative maintenance usually occurs on the third shift and minimizes disruption in the normal operations during the other two shifts. Unexpected maintenance situations and major equipment changes only result in loss of hours when they seriously disrupt the sequencing and completion of normal training operations. In addition, unofficial data from the Guided Missile School at Dam Neck indicate an average of only 5 hours per year of maintenance time lost in laboratories. For these reasons, the 340 hours per year of lost laboratory time should be viewed as a liberal estimate.

The 536 hours loss due to scheduling inefficiency appears to represent conditions which are usually compensated for by rescheduling on short third shift operations and, only in extreme cases, might represent lost time. Situations in which rescheduling could not be accomplished without third shift operations would be rare but could occur. Instead of viewing the 536 hour reduction as scheduling inefficiency and time lost, it is more appropriate to designate the time as the worst case of scheduling inability resulting from unexpected peakloads. These peaks are brought about by possible additional fleet training requirements and abnormally low instructor manning, a situation not uncommon in the POSEIDON program. The 536 hours represent a flexibility factor rather than a seceduling inefficiency loss. The flexibility factor provides a cushion to compensate for laboratory load fluctuations which rise suddenly and then dissipate.

Fleet operational requirements must be provided for as they occur and TRITRAFAC will be in a position to responsibly meet those requirements by regarding the 536 hours as a worst case limit. For example, to meet the unexpected fluctuations, Guided Missile School meetings are conducted on a monthly basis, or as needed, to develop scheduling. Contingency decisions are determined by three alternatives: rescheduling

classes, third shift operations, and/or concurrent training. In the past, by using a combination of these three options, the school has been able to overcome excessive student loads and has successfully met fleet requirements. The same scheduling procedures are expected to be automated for TRITRAFAC.

2.2.3 Overloaded Laboratories

In light of the above, 2,526 was considered to be a comfortable indicator of the yearly available hours for a given laboratory. The number of hours projected by the LDM over 2,526 hours was used to determine laboratory overloads. These hours, when divided by the number of training groups per year at steady state, determined the number of CBI hours required to reduce the load within projected available training hours. The following formula was used to calculate the number of CBI hours:

$$\frac{\text{Projected Yearly Training Hours} - 2{,}526\text{ Hours}}{\text{Number of Training Groups per Year}} = \begin{array}{c}\text{Number of CBI}\\ \text{Hours Required}\end{array}$$

Although 2,526 yearly hours is considered to represent an accurate projection of laboratory time available, contingency CBI hours reflecting less laboratory availability than assumed here were also derived. This is depicted by Table 2-1 which shows additional utilization levels at 69.25% and 64.25% efficiency. These are an additional 5% and 10% of the total 3,402 hours below the 2,526 hour level, respectively. These two projections, while being considered as somewhat unlikely to occur, are provided to aid in further study if unexpected developments occur in the near future.

The results of this methodology were identification of three overloaded laboratories; the Launcher Control Group (LCG), the Fire Control System Unit (FCSU), and the Missile Control Center (MCC) laboratories. At peak yearly loading, which is a steady state, the number of CBI hours required to reduce overloads is 64.25. The 64.25 hours should be distributed among the three laboratories as indicated below.

a. Launcher Control Group

The basic purpose of the LCG is to provide training on equipment used in launching TRIDENT missiles, interfacing launcher subsystems, and testing launcher subsystems. The number of training hours for each class in the LCG is 51 hours for replacement, 38 hours for advanced, and 12 hours for team training. Other training in the LCG takes relatively few hours of laboratory time. Calculations of yearly overloads based on these figures and the number of groups projected in the LDM are seen in Table 2-2.

Table 2-1

Available Training Hours in SWS Laboratories

OPTION	A TOTAL AVAILABLE YEARLY HOURS	B YEARLY HOURS FOR MAINTENANCE AND SCHEDULING	C AVAILABLE YEARLY TRAINING HOURS	D PER CENT OF UTILIZATION OF TOTAL YEARLY HOURS	E ADDITIONAL YEARLY HOURS
A	3,402	876	2,526	74.25	0
B	3,402	876	2,356	69.25	170
C	3,402	876	2,186	64.25	340

Table 2-2

Number of CBI Hours Required in Overloaded Laboratories

OPTION	A	B	C	D	E	F	G
	YEARLY REPLACEMENT HOURS	YEARLY ADVANCED & TEAM TRAINING HOURS	TOTAL YEARLY TRAINING HOURS (A + B)	AVAILABLE YEARLY TRAINING HOURS	NUMBER OF EXCESS HOURS (C - D)	NUMBER OF REPLACEMENT GROUPS PER YEAR	NUMBER OF CBI HOURS (E ÷ F)
LCG							
A	1,367	1,240	2,607	2,526	81	26.80	3.02
B	1,367	1,240	2,607	2,356	251	26.80	9.37
C	1,367	1,240	2,607	2,186	421	26.80	15.71
FCSU							
A	1,170	1,744	2,914	2,526	388	12.66	30.65
B	1,170	1,744	2,914	2,356	558	12.66	44.08
C	1,170	1,744	2,914	2,186	728	12.66	57.50
MCC							
A	1,995	1,204	3,199	2,526	673	26.80	25.11
B	1,995	1,204	3,199	2,356	843	26.80	31.46
C	1,995	1,204	3,199	2,186	1013	26.80	37.80

The actual number of CBI hours required to relieve the laboratory overload at the 2,526 hours level is 3.02 hours of instruction; however, 8.00 hours represents a more attractive hourly allocation for CBI treatment because 3.02 hours might not allow sufficiently flexible scheduling. CBI hours needed to satisfy Option B and C conditions were 9.37 and 15.71 hours, respectively. By adopting 8.00 hours for CBI, Option A nearly coincides with the more stringent requirements of Option B.

b. Fire Control System Unit

The FCSU laboratory provides training on equipments used to support both operator and maintenance functions. Training hours per fire technician class are 92 at the replacement level, 133 in advanced courses, and 17 per group for team training. Calculations of yearly overloads based on these figures and the number of groups projected in the LDM are provided in Table 2-2.

At the 2,526 hour level, approximately 31 CBI hours are required in replacement training to relieve projected overload conditions. This represents approximately one-third of the hours currently being planned for FCSU replacement training. Options B and C present a CBI requirement of 44.08 hours and 57.50 hours, respectively.

c. Missile Control Center

The MCC laboratory encompasses the training of a variety of personnel. A total of 138 replacement training hours are given to a mix of both fire and missile technician students. An additional 10 hours is given to each of the five PCO/PXO groups per year and 58 hours is provided each of the average yearly 6.2 lab groups of SSO/SMO officers. Advanced training requires 49 hours with 17 hours designated for team training. For all of these groups, the MCC laboratory is used to provide system level training. The fire technicians will primarily be concerned with training using the FCS MK98 MOD 0, while the missile technicians will focus upon missile system testing and launcher system/control group operations. The total number of hours dedicated to the MCC laboratory are given in Table 2-2.

A little over 25 (25.25 will be used in the remainder of the study) replacement CBI hours at the 2,526 hours level are required to reduce the MCC overload. Option B would require 31.46 CBI hours, while 37.80 CBI hours would be needed to satisfy Option C.

2.2.4 CBI Considerations for Other FBM Laboratories

There are four additional FBM laboratories, which are not overloaded, at TRITRAFAC: (a) Missile Compartment/Optical Alignment Group (MC/OAG), (b) Segmented Missile, (c) Training Launcher (TL), and (d) Missile Testing and Readiness Equipment (MTRE) Unit. Each of these

laboratories provides training on individual pieces of tactical equipment. Each also has unique characteristics for possible CBI supplementation. The purpose of this paragraph is to document possible directions for CBI should the need arise.

a. Missile Compartment/Optical Alignment Group

CBI applications within MC/OAG would be limited to providing basic normal operations of the Line-of-Sight Subsystem and the Optical Alignment Erection Subsystem control panels and interface equipment to the Fire Control System. Most of the MC/OAG laboratory curriculum deals with hands-on manipulation which limits the range of CBI applications.

b. Segmented Missile

The Segmented Missile laboratory is also involved with physical manipulation of the various laboratory-provided equipment. These include the static missile displays and test equipment used in the P1, C1, C2, and C3 training levels. Possible CBI applications reside in missile system testing. Portions of the guidance testing instruction, emphasizing interface troubleshooting, could be accomplished with CBI.

c. Training Launcher

The use of CBI within the TL laboratory is not promising because most of the training is of a mechanical (manipulatory) nature. Further, the number of hours required for replacement and advanced training are dedicated to the launcher tube. By the use of "mini labs" located around the launcher tube, concurrent training on tube-associated equipment is planned. For this reason, there are few hours obtainable with CBI in the laboratory.

d. Missile Testing and Readiness Equipment Unit

The MTRE Unit represents a condition completely contrary to that of the first three laboratories. CBI can easily supplement all levels of training, even down to C3. After extensive consultation with Guided Missile School instructors at Dam Neck, it was concluded that the MTRE offered an ideal set of characteristics for CBI simulation.

2.2.5 Navigation Laboratories

The Navigation Trainer Installation at TRITRAFAC is composed of six laboratories: (a) Inertial (SINS and ESGM training), (b) ESGM/NAVAIDS, (c) Central Navigation Computer (CNC) Unit, (d) MARDAN/MSR, (e) Supervisor's Console, and (f) Navigation Operational Trainer. Based on projected student throughput and utilization data supplied by Sperry Systems Management, potential overloads may exist in three of the six

laboratories. However, it was beyond the scope of this study to analyze this data in sufficient detail to make specific recommendations for CBI implementation. These projected overloads will need to be investigated by SP-15 and its contractors in the future and are mentioned here only to ensure awareness of the problem.

2.3 CBI Selection and Design Methodology

This section defines a method for selection and preliminary design of CBI for SWS training. The development of such procedures was necessary to provide a systematic approach toward identifying laboratory training which is CBI amenable. The method sets the criteria for a definition of "CBI amenable" and details the steps for applying the definition.

The seven step process is represented in Figure 2-1, Method for SWS CBI Curriculum Selection. The steps require a focus on equipment training requirements and the translation to simulation training by CBI. First, it is necessary to identify each piece of equipment within the laboratory of concern. Second, the level of training, such as normal or casualty and with or without supervision, is to be determined. Third, the actions to be learned within the level are stated. These statements are still at a general level and so a more descriptive statement of instruction is built on the action items in the fourth step. Steps five and six define the simulation requirements by characteristics of the personnel, the task, and the equipment subsystem, and system level operations. Finally, step seven matches the simulation requirements to CBI terminal characteristics which are needed.

The method allows for ranking CBI amenable curriculum within the specific problem context of this study; that is, overloaded laboratories. The method is also specific in other ways to TRIDENT SWS training. It may be noted that the first five steps loosely correspond to SSBN training materials design and development stages. Thus, the methodology is generic; it directly relates to characteristics of the TRIDENT SWS Training System. In future applications, it is recommended that these procedures be refined, detailed, and formalized as part of the training system. While the method was developed in this study for the purpose of determining where and how much CBI could be used in overloaded laboratories, it has the capability of general application to SSBN training with only minor modifications.

It should also be noted that the method, while oriented toward selection of CBI curriculum areas, requires preliminary CBI design. This design process occurs because one must carry the steps through to determination of the terminal characteristics required based on simulation objectives and strategies. By extending the process across the five stages of SSBN curriculum development and production and linking it to specific tasks within the stages, the method presented here can provide a basis for formal SSBN CBI curriculum specification.

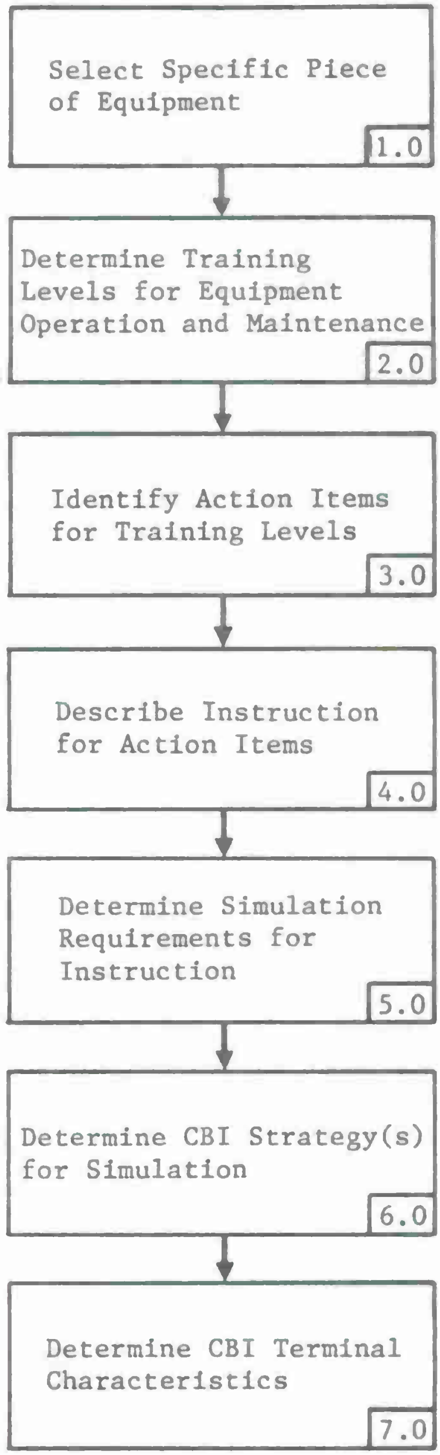

Figure 2-1. Method for SWS CBI curriculum selection

A detailed description of each of the seven steps is provided in the remainder of this seciton.

2.3.1 Equipment Selection

Once a laboratory is determined to be overloaded, it is necessary to select the specific equipment training within the laboratory which can be taught via CBI. The six criteria defined for the selection process are concerned with two general categories: (a) cost-effective CBI courseware development, and (b) cost-effective CBI training operations.

The first three criteria address (a, b, and c) curriculum and documentation characteristics of the equipment training. The importance of these three criteria is that they require the subject matter, which would be put under CBI, to have the least amount of courseware development for the most impact.

The last three criteria (d, e, and f) which are used in selecting equipment for possible CBI implementation, relate to CBI operation within a laboratory; that is, the relationship of CBI as a precursor or summary or intermediary event within the total laboratory sequence and the ease of scheduling such a tactial equipment/CBI laboratory environment.

a. The courseware development effort should result in the largest number of training hours possible with the smallest number of equipment pieces. This criteria is based on the fact that the fewer pieces of equipment to be simulated, the less courseware development and maintenance effort will be required. Fewer subject matter personnel will need to be trained to author CBI material and the time to develop courseware will be less.

b. The CBI courseware developed should provide continuity of context. That is, it is undesirable to break out portions of training for CBI, if leaving the actual equipment allows the high fidelity context of training to be disrupted. This criteria especially applies to long, interdependent training topic areas, such as portions of system level training, which require lengthy sequences of instructional events in order for the student to be familiar with the total context.

c. Courseware development should be based on well-known subject matter, reliably documented. Major portions of TRIDENT curriculum are not documented by task or training requirements to a level sufficient for courseware development. Therefore, the TRIDENT equipment selected in this study are close in concept and operation to documented POSEIDON equipment. As TRIDENT curriculum design progresses, this situation will change. However, because the timeframe for CBI implementation is relatively short, the selection process, and specifically this third criteria, are based on POSEIDON documentation.

d. Skills and knowledge learned under CBI should be reinforced, when possible, by experience with actual equipment. CBI is not intended to replace learning experiences with actual equipment. Therefore, topic areas which provide CBI learning as a precursor to equipment experience are desirable for CBI implementation. In addition, if the precursor skills are to be used during the course of subsequent laboratory instruction, the topic area is considered even more desirable because the CBI learning will be reinforced by equipment experience.

e. CBI implementation should provide for effective CBI scheduling in reducing laboratory overloads. To provide for TRITRAFAC CBI scheduling ease, CBI subject matter should have the ability to encompass large time blocks and possess curriculum discreteness. This will facilitate various possible sequencing modes for scheduling. To support these considerations, CBI candidates are identified and judged on their flexibility for easy adaption to a variety of scheduling modes. In this regard, smaller time slices of 30 minutes to 1 hour are less desirable than those of 1 to 4 hours.

f. CBI implementation should provide for effective scheduling of other laboratory resources. The same criteria as in "e" above, larger CBI time blocks and discreteness of topic, should also allow easier scheduling of learning topics on tactical equipment. This is because the CBI topics would not be totally fixed within a scheduling sequence by either time or dependence on other laboratory learning. The variability of scheduling CBI and other laboratory topics is considered a prime criteria. (This is reflected in the double weighting which results from the same requirements, large time blocks and discreteness, for both criteria "e" and "f.")

The selection of equipment as CBI candidates is based on ranking the equipment within each laboratory by the six criteria described above. Using the form in Table 3-1, the ranking involves: (a) listing each piece of equipment within a given overloaded laboratory (columns labelled A-J), (b) assigning rating values from one to four (one as least desirable and four as most desirable) to each piece of equipment for each of the six criteria, and (c) totaling these ratings for each piece of equipment at the bottom of the form under the heading "TOTAL WEIGHTING." CBI treatment areas for further investigation are selected from the highest weighted pieces of equipment. In subsequent paragraphs of this section, these forms are completed for each of the three overloaded laboratories.

2.3.2 Training Levels

Within the SSBN Training System, curriculum design proceeds by identifying the level of knowledge or skill to be taught. This procedure allows the identification of further training requirements associated with tactical equipment operation or maintenance. Training levels provide a bridge between identification of equipment and corresponding training action items.

Table 2-3

Form for Ranking Laboratory Equipment as CBI Candidates

LABORATORY ______________

REQUIREMENTS	CANDIDATES FOR SELECTION									
MINIMAL NUMBER OF EQUIPMENT PIECES IN COURSEWARE DEVELOPMENT										
CONTINUITY OF TRAINING CONTEXT										
DOCUMENTATION AVAILABILITY										
REINFORCEMENT OF CBI BY OTHER LAB INSTRUCTION										
SCHEDULING EASE OF CBI LESSONS										
PROVIDE FOR EFFECTIVE LAB SCHEDULING										
TOTAL WEIGHTING										
	A	B	C	D	E	F	G	H	I	J

A. ______________
B. ______________
C. ______________
D. ______________
E. ______________
F. ______________
G. ______________
H. ______________
I. ______________
J. ______________

RATING SCALE FOR SELECTION
1---No impact on requirement
2---Very little support of requirement
3---Some support of requirement
4---Able to fully support the requirement

The vehicle, identified in Volume 1 of NAVORD OD 45519, for defining training levels are the Training Objective Statements (TOS). TOS sets organize the skill and knowledge levels by categories of system, subsystem, or equipment, and by a progression of functions; coordinate, direct, and perform. These categories are reflected in Table 2-4, which also defines specific levels.

The TOS also defines the knowledge and skill levels by the items contained in the Personnel Performance Profile (PPP) tables for equipment. According to Volume 1 of NAVORD OD 45519 (Rev. 1, P. 3-15), the Training Level Assignment (TLA):

> a. ". . . Defines the total training requirement for a particular category of personnel (personnel that require the same knowledge and skills) and, therefore, may be used as the means for dividing the total training requirement into . . . categories of training . . .
>
> b. Replacement training--all training required to bring the individual to the . . . 01, 02, P1, and C1 levels of performance . . .
>
> c. Conversion training--all training required to convert personnel from one category to another at all TOS levels of performance . . .
>
> d. Advanced training--all training required to bring the individual from . . . the C1 to C2 levels of performance . . . "

The usefulness of training levels for CBI curriculum selection, design, and implementation is that they provide information on the depth, scope, and type of training associated with hardware operation and maintenance.

2.3.3 Action Items from TOS Sets

Action items are needed to define the equipment training task within a given training level. The TOS sets associate the actions which a trainee must perform on a specific piece of equipment to training levels. Action items also provide a classification of actions which must be performed to satisfy training requirements. Action items found in the Instructor Guides can be compared to the section learning objectives with action verbs such as calibrate, inspect, diagnose, monitor, and coordinate. These classes of actions, when referenced to equipment data as well as training levels, provide equipment oriented task statements as training objectives.

Table 2-4

Training Level Definitions

NAME	GROUP TRAINED	LEVEL	DESCRIPTION OF COVERAGE
Coordinate Task TOS Set	CO/XO Personnel	01	Provides ability required to coordinate all normal and casualty and emergency operational and maintenance procedures.
Direct Task TOS Set	Officer Personnel	01	Provides ability to direct all normal operational procedures.
		02	Provides ability to direct all normal, casualty, and emergency operational procedures.
		M1	Provides ability to direct all maintenance.
Perform Task TOS Set	NEC Personnel	01	Provides ability to perform all normal operational procedures with supervision.
		02	Provides ability to perform all normal operational procedures without supervision and casualty operational procedures with supervision.
		03	Provides ability to perform all normal and casualty operational procedures without supervision.
		P1	Provides ability to perform preventative maintenance with supervision.
		P2	Provides ability to perform preventative maintenance without supervision.
		C1	Provides ability to perform basic fault and minor repair with supervision.
		C2	Provides ability to perform authorized fault isolation and repairs with limited supervision.
		C3	Provides ability to diagnose equipment malfunctions and perform fault isolation, major repairs, and emergency repairs without supervision.

The derivation and cross-referencing of action items, equipment data, and training levels are standard procedures for SSBN Weapon System training. It is accomplished by associating items in the PPPs to TOSs and TLAs. This step in the CBI curriculum selection method, therefore, has a one to one correspondence with current practices non CBI curriculum and requires no additional effort.

For the purpose of the study, POSEIDON training documentation was used to define action items for TRIDENT. This was possible because the action verbs are, by design, stable from one SSBN Weapon System to another. They require qualification by equipment data which is discussed in paragraphs 2.3.4 and 2.3.5 below.

2.3.4 Description of Instruction

The description of instruction was derived from Instructor Guides (IGs) and Job Sheets. Information obtained from the IGs included training goals, discussion points (with related instructor activity), trainee activity, and needed reference material. Job Sheets established measurable trainee performance goals and products for each laboratory training session. Critical information contained in the IGs was reference material used during training. Publications and related procedure guides, such as casualty and standard maintenance procedures, provided further data which allowed determination of specific equipment characteristics and personnel/equipment interface characteristics.

a. Instructor Guides

The POSEIDON curriculum IGs offered sufficient continuity to illustrate a significant portion of TRIDENT laboratory activities. The IGs explained what was being taught in a specific laboratory, how it was being taught, what trainee preparation was required, what trainee materials were required, the sequence of instruction, and what related instructor activity was performed. All of these data inputs were necessary to establish CBI strategies for simulating training on a specific piece of equipment.

b. Job Sheets

Job Sheets were important in determining the interface of the trainee actions and related procedure documentation. The Job Sheets also provided indications of expected student competencies upon completion of the laboratory training and the operation or maintenance procedures of a specific piece of equipment. This allowed a further refinement towards defining CBI simulation requirements.

c. Reference Documentation

Related documentation used in training and on-the-job provided final focus on stimulus and response requirements for specific tactical equipment and trainee laboratory activities. In previous documentation, general instructional requirements were determined. The specific trainee activities required to either operate or repair a piece of equipment were now identified. This provided an indication of trainee/equipment interface characteristics, equipment-to-equipment interface requirements, and the cause and effect relationships of specific operation/maintenance functions.

In the event that the TRIDENT equipment was similar, but not identical to that of the POSEIDON, contractors were solicited to determine what impact equipment modifications would have upon existing POSEIDON curriculum. This input was then evaluated with SWS training experts. The result was used to qualify portions of the instructional descriptions and CBI strategies.

2.3.5 Simulation Requirements

To further define SWS training requirements, it was necessary to determine the simulation and stimulation occuring on tactical and non-tactical equipment in the laboratory. The simulation training provided by the laboratory equipment also sets the criteria for CBI simulation. Thus, both determination of CBI strategies and terminal media characteristics, the next two steps in the selection process, are functions of laboratory equipment simulation.

Three types of simulation can be identified. These are the simulation of: (a) equipment displays and response modes, (b) the interface, or interaction, of personnel with the equipment, and (c) the interface of different equipment units, subsystems, or systems.

The primary source for information on these three types of simulation is the specification for the TRIDENT SWS laboratory controlling unit, the Central Stimulation Complex. Training System Design Specification for Central Stimulation Complex, GEOS 225A2911, provided data on equipment modes, laboratory/equipment connections, training capabilities, and simulation/stimulation required. Typically, TRIDENT operators and, to a large degree, maintenance personnel will receive input from other stations through channeling provided by the tactical equipment itself and will be cognizant of only the information presented in the specific form supplied by the piece of equipment.

a. Equipment Simulation

The simulation requirements for CBI start at the point of equipment component representations. Each piece of equipment is unique but possesses similar display and interface attributes. These attributes,

within TRIDENT, are not that numerous. The equipment attributes are, for instance: actuator/indicators which are illuminated to various colors when actuated; digital readouts which change as the simulation is acted upon and responds; various switch types, such as key activated, toggle, three-digit thumbwheel, and multipositional rotary switches; printer readouts which would complement the actions of a piece of equipment; and insert slots for magnetic tape cartridges. It is these attributes which the trainee is exposed to as he performs equipment operations.

Slightly higher order attributes are needed when maintenance functions are introduced into the simulation. These simulations may require, for example, that the equipment, in the form of equipment drawers and panels of type 2 and 3 modules, be represented on a display with motion indicating placement or replacement. The equipment simulation requirements develop, in many cases, into a hierarchy as the training levels advance. Thus, 01 simulation supports 02, which might require the addition of slightly more components, and P1 directly contributes to providing a C1 simulation base which can be further embellished.

b. Personnel Interface Simulation

Once the equipment simulation requirements have been identified, it is then possible to determine what personnel actions activate the equipment. Personnel actions are translated by the equipment into some meaningful response. The personnel interface simulation requirements are the actions, resulting displays, procedures, and sequences required for training. The interface is bi-directional in that the equipment provides information to the user and the user in turn requests or responds to the equipment.

c. Equipment-to-Equipment Simulation

The simulation requirements for equipment external to that on which training occurs are driven by the need to provide realistic display and response interfaces. While items in a and b above do not require complete high fidelity, there can be no deviation from technical documentation, such as procedural guides. The Central Simulation Complex provides fidelity in the tactical equipment, both to hardware and documentation procedures. Other nontactical equipment is also used to fill this function.

The simulation of tactical equipment must also be considered for CBI implementation. For each piece of equipment selected in the overloaded laboratories, these CBI requirements were analyzed and included in the strategies.

2.3.6 CBI Strategies

At this point all the information pertaining to equipment and instruction is focused on identifying characteristics of the laboratory training which are relevant to CBI design. The possible CBI strategies identified to simulate the training functions of actual laboratory tactical equipment must be viewed as tentative here. They are, however, close approximations of the CBI capabilities which will be used in the actual implementation effort. The same categories used to determine simulation requirements were used to derive CBI strategies.

The identification of CBI strategies includes what aspects of the equipment should be represented in the displays, particular aspects of the display requirements (such as color or symbols), and how the displays should react to varying response modes (such as color or number change as a result of an actuator button push). Many other strategy types, which were not considered significant to the goals of the study, must be developed during final CBI design efforts. These strategies include branching, optimization, adaptive, adjunct, and dynamic techniques as a few examples. All of these may be used, as appropriate in CBI, but they do not relate directly to determination of student/CBI media interface requirements.

a. Equipment Simulation

The CBI strategies for equipment simulation are primarily derived from the instruction descriptions and equipment simulation requirements. The information of interest is the equipment characteristics which will need to be displayed under CBI. The CBI display requirements include panels, equipment displays, knobology, and the fidelity and scope of the task involved. More detailed considerations of these features include extent of symbols (such as alphanumerics or electronic circuits) color, motion, rate of change, and real time needs.

b. Personnel Interface Simulation

Personnel interface CBI strategies were derived from the instructional descriptions and personnel interface requirements of the laboratory tactical equipment. The information of concern is the response and interaction characteristics of the learning task. Emphasis is, therefore, placed on the actions and reactions in the operation and maintenance learning tasks. Specific provisions in the simulation are, for example, operator input by thumb switch or key, color changes on actuator/indicators, and inter-equipment operator messages.

c. Equipment-to-Equipment Simulation

External equipment simulation CBI strategies were derived from the instructional descriptions and external equipment interface requirements

for the laboratory tactical equipment. The information derived is used to set requirements for such items as real time requirements, event sequences, and external message interfaces.

2.3.7 CBI Terminal Characteristics

The seventh and final step in the process for selection and preliminary design of CBI amenable curriculum for SWS training is determination of the terminal media characteristics. There are two purposes for inclusion of this step in the methodology. First, the definition of "amenable" becomes extended to include only those topics which can be delivered to the student by state-of-the-art CBI. That is, since the simulation requirements and CBI strategies have been identified it is now possible to match them against available terminal characteristics.

Further, since the CBI terminal is the instructional media or delivery system, it is appropriate that specifications for the terminal be included in the analysis of training rather than being based on computing factors. This latter concept leads to the second purpose. The identification of requirements for terminal media characteristics provides the initial step in selecting and configuring the total CBI systems which meet TRIDENT SWS training needs. Subsequent paragraphs of this section, in fact, uses the results derived from analysis of terminal media requirements in the overloaded laboratories to determine the overall terminal configurations. The latter is then used in section 3 as a base for matching SWS requirements against CBI systems.

The media characteristics of interest are divided into two general categories: (a) display and (b) response. Display characteristics included for consideration were dynamic graphics, static graphics, photographic overlays or separate displays, color, alphanumerics, resolution, and audio. Response characteristics considered included position indicators such as touch panels and stylus, types of keyboards, and special function response units. Each of these, and others, were matched to the possible strategies determined for SWS topics selected for CBI.

2.4 Launcher Control Group Laboratory

The MK 13 MOD 0 Launcher Control Group (LCG) will be composed of the equipment required to control and monitor the status of the launcher subsystem and each of the 24 launchers during the many conditions of SWS operation. The LCG will also monitor the status of certain operational functions related to launcher operation in fire control, missile, and ship subsystem functions.

A total of seven equipments in the LCG were studied for CBI amenability. These are the Launcher Control Console (LCC), Launch Safing Assembly (LSA), Built-In Test Equipment (BITE), Missile Tube Logic and

Control Assembly (MTLCA), Subsystem Logic Control and Alarm Assembly (SLCAA), Power Detonator Assembly (PDA), and Missile Tube Alarm Assembly (MTAA). The LCC and the equipment cabinet for the LSA will be located in the Missile Control Center, while other LCG related equipment will be located in the Missile Compartment.

2.4.1 Equipment Selection

After the LCG laboratory was identified as being overloaded, each piece of associated equipment was examined in terms of its ability to support the six selection criteria discussed in paragraph 2.3.1. The result of that analysis is depicted in Table 2-5. Two pieces of equipment, the LCC and the BITE, were determined to be prime LCG CBI candidates. The other LCG equipments ranked lower because of the lack of continuity in training context, the lack of available TRIDENT or POSEIDON documentation due to the upgrade from 16 to 24 missiles, and the lack of reinforcement by other laboratory instruction.

The LCC was ideally suited for CBI treatment. CBI can be used for 01 and 02 training level functions with minimal courseware development since the same front panel display representations would be used for interface with the student. Also, documentation from POSEIDON was available to support the study of CBI strategies. By focusing at the 01 and 02 training levels, CBI would provide continuity in topic areas which would need little support from other laboratory instruction. At the same time, however, the CBI-acquired LCC skills would be demonstrated and practiced during the operation of the LCG equipment in the laboratory. In addition, because the CBI lessons stand well by themselves, the LCC training on CBI would be easy to schedule and would provide ease in scheduling the remaining LCG laboratory hours. An extra benefit in selecting the LCC would be the possible transference of the CBI lesson to either SSO/SMO orientation courses or team training remedial efforts.

The BITE was equally impressive for CBI treatment. Although comparable to the LCC on most of the selection criteria, the BITE, being a new piece of equipment, was not involved in any prior training experiences. To extensively train on the BITE would require the simulated inputs of other LCG equipments, their associated drawer characteristics, and adjunct maintenance documentation. These requirements, without documentation, could enlarge the courseware development effort and, for this reason, the BITE was not as attractive a CBI candidate as the LCC. The BITE is a candidate for consideration if later TRITRAFAC situations necessitate additional CBI treatment within the LCG. In addition, the BITE is the focal point for fault isolation (except for the LCC) during replacement training and, as such, can facilitate instructional continuity to other equipment.

Table 2-5

LCG Laboratory CBI Candidates by Ranking

LABORATORY LAUNCHER CONTROL GROUP (LCG)

REQUIREMENTS	CANDIDATES FOR SELECTION									
MINIMAL NUMBER OF EQUIPMENT PIECES IN COURSEWARE DEVELOPMENT	4	2	2	2	2	2	3			
CONTINUITY OF TRAINING CONTEXT	4	4	2	2	2	4	4			
DOCUMENTATION AVAILABILITY	4	2	1	1	1	2	1			
REINFORCEMENT OF CBI BY OTHER LAB INSTRUCTION	4	2	2	2	2	2	4			
SCHEDULING EASE OF CBI LESSONS	4	4	4	4	4	4	4			
PROVIDE FOR EFFECTIVE LAB SCHEDULING	4	2	2	2	2	2	4			
TOTAL WEIGHTING	24	16	13	13	13	16	20			
	A	B	C	D	E	F	G	H	I	J

A. LCC
B. LSA
C. MTLCA
D. SLCAA
E. MTAA
F. PDA
G. BITE
H.
I.
J.

RATING SCALE FOR SELECTION
1---No impact on requirement
2---Very little support of requirement
3---Some support of requirement
4---Able to fully support the requirement

2.4.2 LCC Description

The LCC will contain displays and controls used by the launch supervisor to control and monitor the launcher subsystem during different readiness conditions as well as during loading, subsystem testing, launching, and jettisoning operations. The LCC panels are the primary personnel interface and are grouped by functions performed.

There are six basic panels in the LCC. Each has a separate function and is composed of various alarms, actuator/indicators switches, and light emitting diodes. In addition to the six LCC panels, a Missile Monitor Signal Conditioner (MMSC) will be mounted on the LCC.

a. The Launcher Console Status Panel consists of 24 subpanels arranged in vertical columns. Two actuator/indicators on each panel will be used to initiate pressurization or impose manual hold. A digital readout will indicate launcher tube air pressure. Indicators will be illuminated for status conditions.

b. Launcher Switch Modules consists of switches required to control the hatch, access doors, and pressure supply vent valves for each launcher.

c. The Launcher Console Subsystem Panel consists of three-position toggle switches to select pressurization, pressurization rate, sea sensing header value position, launch mode and hydraulic value position. A three-position, key actuated switch will set the operating mode. A Missile Compartment station manning button is provided. A three-digit thumbwheel type switch and digital readout will indicate tube number.

d. The Alarm Panel will consist of red and amber switchlight indicators. Six columns of switch indicator lights will display launcher operational status. Sixteen operational alarms and 27 status alarms are displayed. A light emitting diode will indicate tube number. System alarms will be displayed in three columns. Twenty-four system alarm indicator lights are either red or amber; red alarms will denote immediate action and amber alarms indicate when an operator exercises caution, recheck, or unexpected delay actions.

e. The Jettison Panel contains a key actuated switch to activate the panel. Twenty-four actuator/indicator buttons are used for selecting a given launcher for missile jettisoning. A prepare actuator/indicator will generate either a "Denote" or "Prepare" signal.

f. The Environmental Readout Panel will consist of meters with white alphanumeric values on black background. The meters display, in digital form, the launcher environmental conditions including temperature, humidity and pressure. Temperature is displayed on two separate meters to the nearest tenth of a degree Fahrenheit. Humidity condition is displayed

on two separate meters with reading shown in percent of relative humidity. Pressure is displayed on four separate meters with readings shown in tenths of a pound.

2.4.3 CBI Selection Analysis for LCC

In examining the LCC for specific CBI attributes, it was determined that the LCC offered excellent treatment within the 01 and 02 training levels. From the laboratory utilization analysis, discussed in paragraph 2.2, the number of laboratory hours to be supplemented by CBI was established at 8. These 8 hours were divided evenly into two 4-hour blocks of CBI at the 01 and 02 levels in replacement courses. It should be noted that these two 4-hour blocks do not cover every LCC 01 and 02 training requirement. Only those which were deemed appropriate for CBI using the methodology developed in paragraph 2.3 were included in this analysis. A summary description of the suitable training topic areas is provided in Table 2-6 and discussed further below.

After the number of hours were derived, the analysis addressed the overall training goal, or goals, encompassed within a specific training level (identified in the column marked "Action Items"). For the LCC, the 01 level entailed normal operating procedures with supervision at both surfaced and submerged modes, while the 02 level demanded the additional requirements of normal operating procedures without supervision and casualty procedures with supervision. The analysis also provided a description of the salient points of the instruction which would be addressed in the CBI laboratory treatment (third column). The CBI topic time allotments were based upon POSEIDON training, TRIDENT requirements, and CBI simulation general experience.

The simulation requirements were then determined for the LCC in three areas: (1) what the equipment would provide to the operator in terms of displays and components, (2) how the operator would interact with the LCC and associated equipment, and (3) what outside equipment-to-equipment inputs and outputs would be needed to provide a realistic scenario of operations for the trainee. After the identification of attributes pertinent to each of these areas, the CBI required terminal characteristics were listed.

2.4.4 Results of CBI Analysis

It was determined that all LCC instruction and identified equipment displays, components, and interactions could be adequately provided for by CBI technology. By the use of a wide range of terminal characteristics, supplementing the laboratory equipment by CBI can be achieved in sufficient quality and quantity to account for the two 4-hour time periods at the 01 and 02 levels. Specific unique characteristics brought to light by the analysis are worthy of mention.

Table 2-6

LCG Hours Selected for CBI in LCC

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
01 [a]	1.1 Perform normal operating procedures for LCC, including both surfaced and submerged modes with supervision	2.1 Perform the following procedures on LCC. a. SQ line-ups b. WSRT c. Tactical Launch in accordance with documentation by positioning LCC switches and actuators/indicators in the proper normal operating modes with supervision	3.1 Equipment to Operator a. Actuators/indicators b. Illumination of (a) c. Digital readouts d. Key switches e. Toggle switches f. Three-digit thumb-wheel switch	4.1 Equipment Simulation a. Simulate the following launcher panels: (1) Console status (2) Switch modules (3) Console subsystem (4) Console alarm (5) Jettison (6) Environmental readout b. Simulate MMSC panel c. Provide for at least 4 colors on actuators/indicators d. Provide for a range of alphanumeric values	High Resolution, Dynamic Graphics, Picture Display. Color or Color Designation Capability. Programmable Symbol Generation with Fast Response Time.
			3.2 Operator to Equipment a. Physical manipulation of 3.1	4.2 Operator Interface a. Provide for movable switching positions b. Provide for appropriate color and illumination c. Provide for operator input	Dynamic Graphics. Color or Color Designation Touch or Stylus Input.
			3.3 Equipment to Equipment a. FC simulation for LCG b. FC switchboard c. Launcher tube (24) d. EBW (24) e. SWSSCMP f. MMSC (24) g. Ship subsystems h. Spare guidance TMPS	4.3 Equipment-to-Equipment Simulation a. Provide for real/time responses b. Provide for proper sequencing c. Ensure compatibility with documentation	Fast Response Time. Ease in Authoring and Editing from Keyboard.
02 [a]	1.1 Perform all normal operating procedures without supervision and casualty procedures with supervision for LCC, including both surfaced and submerged modes	2.1 Perform all normal and casualty operations with supervision on the LCC during a Strategic Launch, utilizing all Casualty Procedures (CPs) immediate and deferred actions and all Weapon Operation Procedures (WOPs)	3.1 Equipment to Operator a. Same as 01 level b. Status report input	4.1 Equipment Simulation a. Same as 01 level b. Audio reports from relevant areas of the launch system	Same as 01 level Simulation of Audio messages by "message window" or Dual Display
			3.2 Operator to Equipment a. Same as 01 level b. Response to 3.1 (b)	4.2 Operator Interface a. Same as 01 level b. Acknowledgement of 4.1(b) above and appropriate actions	Same as 01 level Function Keys or Touch/Stylus Input
			3.3 Equipment to Equipment a. Same as 01 level	4.3 Equipment-to-Equipment Simulation a. Same as 01 level	Same as 01 level
		2.2 Perform coordinated LCC panel and Jettison panel operations to perform a submerged jettison operation in accordance with documentation	3.4 Equipment to Operator a. Same as 3.1 b. Display for coordination effects	4.4 Equipment Simulation a. Same as 4.1 level b. Display of LCC panels	Same as 01 level Picture or Graphic with Color or Color indicators
			3.5 Operator to Equipment a. Same as 3.2	4.5 Operator Interface a. Same as 4.2	Same as 01 level
			3.6 Equipment to Equipment a. Same as 01 level	4.6 Equipment-to-Equipment Simulation a. Same as 01 level	Same as 01 level

[a]Number of Laboratory Hours Replaced: 4

The analysis did not attempt to provide total integration of knowledge and skills at a system or subsystem level on CBI. It was felt that system level concepts could be better provided with the laboratory equipment.

It was determined that a large amount of equipment interfaces would be essential in both 01 and 02 levels. However, while this is true for the actual equipment, the displays channel this multitude of differing input/output signals into actuators/indicators, switches, and readouts. The trainee under CBI doesn't actually need a switchboard, for example, but he does need a representation of the input/output action on the switchboard and a particular indicator, procedure, or process on the LCC. This function can be performed by CBI as well as the actual LCC. The CBI programming will take into account equipment-to-equipment requirements for the LCC by the proper sequencing of responses in real time and compatibility with existing documentation.

At the 02 level, it was determined that the trainee receives instructional experiences not only from the LCC displays but also from the audio interchange between himself and other watch-stations throughout the FBM system. This characteristic suggested including an audio system in the CBI terminal. To successfully meet this instructional requirement, a "canned" voice output or displayed text would be sufficient and trainee input could be in the form of simplified keyboard responses.

Also at the 02 training level, the requirement existed to provide for deferred actions by the trainee during countdowns and testing operations. This required the inclusion of sufficient memory within the CBI terminal to store, sort, and prioritize these deferred actions.

Closely related to all the instruction provided by the LCG is the need to tie existing documentation tightly into the CBI instruction. It is necessary for the CBI lessons to be driven in large part by the documented sequences, procedures, and processes.

Lastly, coordinated activities will be required by the operator when utilizing different panels on the LCC. The Jettison Panel, for example, will require coordinated efforts with the other LCC panels in order to demonstrate all required operations. For this reason, display of both panels simultaneously was suggested to convey to the trainee what the coordination would entail within the jettisoning operation.

2.4.5 Recommendations for Additional CBI Treatment

Included within the laboratory overload analysis, described in paragraph 2.2.2, was the provision for additional CBI hours should the need arise. The following CBI analysis for the LCG is provided to meet any such future developments.

2.4.5.1 Additional CBI Hours on LCC Topic Areas

An additional three CBI hours were identified for LCC consideration and are included in Table 2-7. The one hour at the P1 level would basically consist of having the trainee become familiar with the documentation resources required for preventive maintenance upon the various LCC components. Two hours were designated for CBI treatment at the C1 training level, as seen in Table 2-7. As with the proposed P1 treatment, the documentation-to-equipment-to-trainee interface was stressed. It was determined that maintenance activities, in the form of recognition and interpretation of malfunctions, could be performed by CBI. Training by CBI in the maintenance areas would not be designed to completely supersede conventional laboratory training but would only be focused at providing "advanced organizers" and procedural tutorial assistance before the trainee was exposed to the actual laboratory experience. This would accomplish a more positive and productive utilization of the trainee's time and efforts when he eventually encountered specific maintenance malfunction problems in the laboratory, thus enhancing greater laboratory skills learning on the part of the trainee.

2.4.5.2 CBI Hours on BITE Topic Areas

Built-in test equipment (BITE) will be located in one electronic equipment enclosure within the LCG. All BITE components will be housed within this equipment enclosure. Components will include a mini-computer, a drawer test slot, a relay test slot, standard electronic modules, a control panel printer, power supplies, a magnetic tape reader for software (on cartridges) required for programming the computer for the needed test, and input/output interface circuitry.

BITE will possess the capability of testing separate LCG equipment drawers, standard electronic modules, and relays. The identification of faults will occur down to groups of six or fewer modules or relays. Self-testing of the BITE will also occur along with the maintenance testing of its own printer, tape recorder, and interface circuitry components. The LCG equipment drawer tests will consist of monitoring drawer outputs for positive or negative responses. Individual tests are selected on the BITE control panel and test sequences are computer controlled. Test results for each step are stored with faults being printed for action. Both fault description and location information will be provided. Maintenance will be performed by isolating suspected faulty modules and then testing the module in the standard electronic module test slot.

Six hours were identified as possible CBI hours in the laboratory instruction pertaining to BITE. These six hours were composed of the following breakdown: one hour for O1 training, two hours for O2 training, one hour for P1 training, and two hours for C1 training. The analyses of these six hours by training level are provided in Table 2-8.

Table 2-7

Additional LCG CBI Hours in LCC

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
C1 [a]	1.1 Perform basic fault isolation and minor repair with supervision on LCC	2.1 Recognize and interpret indication of malfunctions and perform basic fault isolation procedure contained in prescribed documentation. This instruction is focused at relay and module failure.	3.1 <u>Equipment to Operator</u> a. Same as 01 and P1 levels b. Associated test equipment c. LCC components (1) Standard electronic modules (SEM's) (2) Relays	4.1 <u>Equipment Simulation</u> a. Same as 01 and P1 levels b. Simulate associated test equipment panels and appropriate readings corresponding to documented parameters c. Provide for both graphic and pictorial representations of LCC components	Same as 02 level
			3.2 <u>Operator to Equipment</u> a. Same as 01 and P1 levels b. Provide for operator coordination between LCC components and associated test equipment functions	4.2 <u>Operator Interface</u> a. Same as 01 and P1 levels b. Provide for both graphic and pictorial representations of LCC components and associated test equipment and dual display	Same as 02 level
			3.3 <u>Equipment to Equipment</u> a. Same as 01 and P1 levels b. LCC components for associated equipment	4.3 <u>Equipment-to-Equipment Simulation</u> a. Same as 01 and P1 levels	Same as 01 level
	1.2 Perform operational tests for basic corrective maintenance	2.2 Perform alignment, adjustment or calibration procedures and operational tests for basic corrective maintenance in accordance with documentation. The instruction at this point stresses operational testing which should not differ greatly from the basic functions provided in 2.1	3.4 <u>Equipment to Operator</u> a. Same as 3.1 b. LCC components	3.4 <u>Equipment Simulation</u> a. Same as 4.1	Same as 02 level
			3.5 <u>Operator to Equipment</u> a. Same as 3.2 b. Provide for operator coordination between LC components and associated test equipment functions	4.5 <u>Operator Interface</u> a. Same as 4.2	Same as 01 level
			3.6 <u>Equipment to Equipment</u> a. Same as 3.3	4.6 <u>Equipment-to-Equipment Simulation</u> a. Same as 4.3	Same as 01 level
	1.3 Use test equipment required for basic corrective maintenance	2.3 Perform postrepair procedures in accordance with documentation	3.7 <u>Equipment to Operator</u> a. Same as 3.4	4.7 <u>Equipment Simulation</u> a. Same as 4.4	Same as 02 level
			3.8 <u>Operator to Equipment</u> a. Same as 3.5	4.8 <u>Operator Interface</u> a. Same as 4.5	Same as 02 level
			3.9 <u>Equipment to Equipment</u> a. Same as 3.3	4.9 <u>Equipment-to-Equipment Simulation</u> a. Same as 4.3	Same as 01 level
		2.4 Use test equipment required for basic corrective maintenance in accordance with documentation for specific repair situations	3.10 <u>Equipment to Operator</u> a. Same as 3.4 with insertion of specific repair problems	4.10 <u>Equipment Simulation</u> a. Same as 4.4	Same as 02 level
			3.11 <u>Operator to Equipment</u> a. Same as 3.5 with insertion of specific repair problems	4.11 <u>Operator Interface</u> a. Same as 4.5	Same as 02 level
			3.12 <u>Equipment to Equipment</u> a. Same as 3.3 with insertion of specific problems	4.12 <u>Equipment-to-Equipment Simulation</u> a. Same as 4.3	Same as 01 level

[a] Number of Laboratory Hours Replaced: 2

Table 2-7 (Continued)

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
P1 b	1.1 Perform preventative maintenance procedures with supervision on LCC in accordance with documentation	2.1 Perform basic preventative maintenance procedures as presented in the SMP/SOP, including operational test procedures as required by applicable documentation. This section entails <u>only the use of the documentation</u> on PM and operational testing procedures for representative preventative maintenance problems.	3.1 <u>Equipment to Operator</u> a. Same as 01 level b. Graphics and pictorial representation of equipment and procedures	4.1 <u>Equipment Simulation</u> a. Demonstration of hands-on application b. Simulation of circuit breaker switches c. Associated test equipment	Same as 02 level
			3.2 <u>Operator to Equipment</u> a. Same as 01 level b. Ability to follow PM procedures and operational test procedures	4.2 <u>Operator Interface</u> a. Interrogation by operator of pertinent documentation and procedures	Same as 02 level
			3.3 <u>Equipment to Equipment</u> a. Same as 01 level b. Power to circuit breaker switches c. Associated test equipment to LCC components	4.3 <u>Equipment-to-Equipment Simulation</u> a. Same as 01 level	Same as 01 level

[b] Number of Laboratory Hours Replaced: 1

Table 2-8

LCG Hours Selected for CBI in BITE

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
01 [a]	1.1 Perform normal operating procedures for BITE with supervision	2.1 Perform the following procedures on BITE: a. Power up b. Operate control panel in accordance with proper documentation by positioning BITE switches and actuator/indicators in the proper normal operating modes when testing BITE and other LCG equipment drawers	3.1 Equipment to Operator a. Actuator/indicators b. Illumination of (a) c. Switches d. Printer readouts e. Slots f. Cartridges	4.1 Equipment Simulation a. Simulate the following: (1) Power supplies (2) Control Panel (3) Printer (4) Drawer, relay, SEM slots (5) Magnetic tape reader (6) Cartridges b. Provide for at least 4 colors c. Provide for range of alphanumeric values d. Provide for printout	High Resolution, Picture or Graphic Capability Color or Color Indication Programmable Symbols and Fast Response/Display
			3.2 Operator to Equipment a. Physical manipulation of 3.1 b. Analysis of 3.1 (d) c. Insertion of 3.1 (f) into 3.1 (e)	4.2 Operator Interface a. Provide for movable switching positions b. Provide for appropriate color and illumination c. Provide for operator input	Dynamic Graphics Color or Color Indication Touch or Stylus Input
			3.3 Equipment to Equipment a. Power supplies to BITE b. Cartridge to appropriate BITE testing programs	4.3 Equipment-to-Equipment Simulation a. Provide for real time responses b. Provide for proper sequencing c. Ensure compatibility with documentation	Fast Response Time Ease in Authoring and Editing through Terminal
02 [b]	1.1 Perform all normal operating procedures without supervision and casualty operational procedures with supervision	2.1 Perform the following procedures on BITE: a. Test selected launch safing assembly drawers b. Test selected subsystem logic and control assembly drawers c. Test selected subsystem logic control and alarm assembly drawers d. Test selected detonator power assembly drawers in accordance with established documentation by operation of control panel, selection of proper cartridges and insertion, and monitoring of printer readout in the normal casualty modes of operation	3.1 Equipment to Operator a. Same as 01 level b. Designation of selected drawers itemized from instruction description	4.1 Equipment Simulation a. Same as 01 level b. Simulation of selected from instruction description	Same as 01 level Pictorial or Graphics Display with color or color indication
			3.2 Operator to Equipment a. Same as 01 level b. Provide for documentation interface with testing of selected equipment drawers	4.2 Operator Interface a. Same as 01 level b. Provide documentation c. Because of (b) provide display for documentation and printout	Same as 01 level Dual Display or Split Screen or Window of Documentation Text with Panel Display
			3.3 Equipment to Equipment a. Cartridge to proper BITE programs b. Selected equipment drawer to BITE	4.3 Equipment-to-Equipment Simulation a. Same as 01 level	Same as 01 level
P1 [a]	1.1 Perform normal preventative maintenance procedures with supervision on BITE in accordance with documentation	2.1 Perform preventative maintenance procedures as presented in the SMP/SOP, including operational testing procedures as required by applicable documentation. This section of instruction is of the prescribed documentation on preventative maintenance and operational testing procedures for representative maintenance problems on BITE by self-testing. Associated equipment components such as printer, tape reader and interface circuitry would be included	3.1 Equipment to Operator a. Same as 01 level b. Breakdown of equipment to component location and physical dimensions	4.1 Equipment Simulation a. Same as 01 level b. Visual display of 3.3 Items c. Visual display demonstration of PM activities	Same as 01 level Graphic or Pictorial Display
			3.2 Operator to Equipment a. Same as 02 level	4.2 Operator Interface a. Same as 02 level	Same as 01 level
			3.3 Equipment to Equipment a. Cartridge to proper BITE programs b. Printer to BITE c. Tape reader to BITE d. Interface circuitry to BITE e. Items (a) through (d) to documentation	4.3 Equipment-to-Equipment Simulation a. Same as 01 level	Same as 01 level

[a]Number of Laboratory Hours Replaced: 1

[b]Number of Laboratory Hours Replaced: 2

Table 2-8 (Continued)

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
C1[b]	1.1 Perform basic fault isolation and minor repair with supervision on BITE components with BITE or special test equipment if needed.	2.1 Recognize and interpret indications of malfunctions and perform basic fault isolation procedures contained in prescribed maintenance documentation. This instruction is focused at relay, module, and limited number of movable parts possible contained in the printer, tape reader, and control panel	3.1 Equipment to Operator a. Same as P1 level b. Breakdown to illustrate movable parts c. Special test equipment if needed	4.1 Equipment Simulation a. Same as P1 level b. Demonstration of corrective maintenance activities	Same as P1 level
			3.2 Operator to Equipment a. Same as O1 level b. Documentation interface with basic fault isolation of BITE components on BITE or special test equipment if needed.	4.2 Operator Interface a. Same as O2 level	Same as O1 level
			3.3 Equipment to Equipment a. Same as P1 level b. BITE components to BITE self test and special test equipment if needed	4.3 Equipment-to-Equipment Simulation a. Same as O1 level	Same as O1 level
		2.2 Perform alignment, adjustment or calibration procedures and operational tests for basic corrective maintenance in accordance with documentation. The instruction stresses operational testing.	3.4 Equipment to Operator a. Same as 3.1	4.4 Equipment Simulation a. Same as 4.1	Same as P1 level
			3.5 Operator to Equipment a. Same as 3.2 b. Test interface	4.5 Operator Interface a. Same as 4.2	Same as O1 level
			3.6 Equipment to Equipment a. Same as 3.3	4.6 Equipment-to-Equipment Simulation a. Same as 4.3	Same as O1 level
		2.3 Perform post repair procedures in accordance with documentation	3.7 Equipment to Operator a. Same as 3.1	4.7 Equipment Simulation a. Same as 4.1	Same as P1 level
			3.8 Operator to Equipment a. Same as 3.2	4.8 Operator Interface a. Same as 4.2	Same as O1 level
			3.9 Equipment to Equipment a. Same as 3.3	4.9 Equipment-to-Equipment Simulation a. Same as 4.3	Same as O1 level
		2.4 Use test equipment required for basic corrective maintenance in accordance with documentation for specific repair situation	3.10 Equipment to Operator a. Same as 3.1 with insertion of specific repair problems	4.10 Equipment Simulation a. Same as 4.1	Same as P1 level
			3.11 Operator to Equipment a. Same as 3.2 with insertion of specific repair problems	4.11 Operator Interface a. Same as 4.2	Same as O1 level
			3.12 Equipment to Equipment a. Same as 3.3 with insertion of specific problems	4.12 Equipment-to-Equipment Simulation a. Same as 4.3	Same as O1 level

[b]Number of Laboratory Hours Replaced: 2

2.5 Fire Control System Unit Laboratory

The TRIDENT Fire Control System MK 98 MOD 0 (FCS) provides two main services: (a) the preparation of missiles for sequential launching with self-guidance after launch, and (b) the coordination of operations in the SWS during the launch sequence. Missile preparation consists of supplying prelaunch power, guidance system data, fuze data, and monitoring the status of the guidance system in each missile. FCS SWS coordination consists of monitoring systems involved in sequential functions at appropriate times. In the coordination, FCS receives data on navigation status and time of day, launcher status, missile status, guidance system status, fire control status, and ship's power.

To accomplish these tasks, the FCS is subdivided into six functional groups and one utility group. The six functional groups are: (a) Digital Computations Subsystem Group, (b) Computer Peripheral Subsystem Group, (c) Computer Interface Subsystem Group, (d) Control, Display, and Switching Subsystem Group, (e) Optical Alignment Subsystem Group, and (f) Temperature Monitor Power Supply and Spare Guidance Temperature Monitor (TMPS and SGTM) Subsystem Group. A seventh group, the Utility Group, is comprised of the Power Subsystem (PWRSS). These major groups are further subdivided in Table 2-9.

To provide an overall picture of the FCS operating environment, three concepts are helpful: conditions of readiness, software programs, and operating modes. Conditions of readiness are states of weapon system preparedness from which the FCS can be made to start the launch of all 24 missiles within specified time limits. The conditions are designated 4SQ, 3SQ, 2SQ, and 1SQ. All software programs operate under two levels of control programs: a monitor program and one of several executive programs. All application task programs fall into one of three categories according to use: tactical, training, or maintenance (TEST). The FCS is capable of performing tasks in 12 primary operating modes and three secondary modes. This capability is to satisfy the requirements of maintenance, training, and data processing. The twelve primary modes are tactical, dummy, training with Guidance/with Launcher (TWIGL), training with Guidance (TWIG), training without Guidance/with Launcher (TWOGL), training without Guidance (TWOG), missile test, fire control test, fuze test, data entry, standby, and off.

Although the most important operating mode is the tactical mode, the FCS, to meet system readiness and reliability standards, must be capable of detecting, isolating, and resolving fire control equipment faults. Under casualty conditions, it must be capable of reconfiguration to bypass the casualty and continue tactical operations.

Table 2-9

Groups Within FCSU Laboratory

Group	Components
Functional:	
1. Digital Computations Subsystem Group	Basic Processor Subsystem (BPSS) Data Communication Processor Subsystem (DCPSS) Computer Maintenance Subsystem (CMSS) Computer Operator Interface Subsystem (COISS) Digital Control Computer (DCC)
2. Computer Peripheral Subsystem Group	Magnetic Disk File Subsystem (MDFSS) Printer Subsystem (PRTSS) Keyboard and Display Subsystem (KBDSS) Magnetic Tape File Subsystem (MTFSS)
3. Computer Interface Subsystem Group	Data Conversion Subsystem (DCSS) Time of Day Subsystem (TODSS) Digital Read-in Subsystem (DRISS)
4. Control, Display, and Switching Subsystem Group	Control and Display Subsystem (CDSS) Master Clock and Timing Subsystem (MCTSS) Switching Subsystem (SWSS) Test Control and Display Subsystem (TCDSS)
5. Optical Alignment Subsystem Group	Line of Sight Subsystem (LOSSS) Optical Alignment Erection Subsystem (OAESS)
6. Temperature Monitor Power Supply and Spare Guidance Temperature Monitor Subsystem Group	Temperature Monitor Power Units Spare Guidance Temperature Monitor Units
Utility	
1. Power Subsystem Group	Power Distribution Equipment Power Conversion Unit Digital and Analog Power Supplies

2.5.1 Equipment Selection

The six functional groups in the overloaded FCSU laboratory are knowledge-oriented content areas which could support in-depth CBI courseware development. However, interfaces with equipment outside the respective functional areas require some interaction between groups. The Digital Computations Subsystem Group, for instance, will require the inclusion of KBDSS to support P1 and C1 training requirements of the DDC Computer Programs. The requirement for POSEIDON equipment similarity and documentation support identified three groups as potential CBI candidates: (a) the Control, Display, and Switching Subsystem Group, (b) the Digital Computations Subsystem Group, and, to a somewhat lesser degree, (c) the Computer Peripheral Subsystem Group. The OAG and TMPS and SGTM were not seen as reasonable candidates for analysis. The ranked results of the equipment selection are presented in Table 2-10.

Under the criteria for continuity of training context, two candidates were judged as outstanding in their ability to provide both instructional flow and equipment contiguity: (a) the Control, Display, and Switching Subsystem Group as embodied in the Fire Control Console (FCC); and (b) the Digital Computations Subsystem Group with the addition of the KBDSS. In both of these groups, equipment contiguity was found essential to support the other equipment within the specific group. Simulation requirements for equipment functional displays possessed the ability to transfer to a second or third piece of equipment. Thus, courseware development and curriculum continuity were mutually supported by selection of these two groups.

Both of these groups can be treated either in part-task, equipment unit, or functional group instructional strategies. If desired, at a later date, CBI courseware could be used to provide a unifying thread to tie equipment together in more system oriented training. In view of these considerations, the Digital Computations Subsystem Group (composed of the DDC, DDC Computer Programs, BPSS, DCPSS, COISS, CMSS, and KBDSS) and the Control, Display, and Switching Subsystem Group (composed of CDSS, TCDSS, PRTSS, and TODSS) were selected for further CBI analysis.

2.5.2 FCC Description

The Control, Display, and Switching Subsystem Group located on the FCC performs four functions: (a) operator control of FCS operations, (b) display of FCS and weapon systems status, (c) clock and timing signals generation, and (d) selection and control of FCS maintenance, guidance system, and missile testing. It also interfaces directly with the launcher, navigation, MTRE, TMPS, and SGTM by transmitting sequence control signals and receiving reports of launch tube, missile, guidance system, and navigation status. Alarm conditions within the FCS are also monitored and displayed.

Table 2-10

FCSU Laboratory CBI Candidates by Ranking

Requirement	Candidates for Selection																
	Group 1					Group 2					Group 3			Group 4			Util.Gp.
	DCC	DCC Comp. Prog.	BPSS	DCPSS	CMSS	COISS	MDFSS	KBDSS	MTFSS	PRTSS	DRISS	DCSS	TODSS	MCTSS	CDBS	TCDSS	PWRSS
Minimal number of equip. pieces in courseware development	4	4	3	3	4	4	2	4	4	4	2	2	4	2	4	4	3
Continuity of training context	4	4	4	4	4	4	3	4	3	4	3	2	4	3	4	4	4
Documentation availability	2	2	2	2	2	2	4	3	4	2	2	2	2	3	4	4	3
Reinforcement of CBI by other lab instruction	4	4	4	4	4	4	2	4	2	4	2	2	3	2	4	4	3
Scheduling ease of CBI lessons	4	4	4	3	4	4	4	4	3	4	4	4	4	4	4	4	4
Provide for effective lab scheduling	3	4	4	4	3	3	2	3	3	3	3	2	3	2	4	4	3
Total weighting	21	22	21	20	21	21	17	22	19	21	16	14	20	16	24	24	20

Rating Scale:
1 = No impact on requirement.
2 = Very little support of requirement.
3 = Some support of requirement.
4 = Able to fully support the requirement.

The FCS is capable of operating in the 12 primary modes, listed in paragraph 2.5, and three secondary modes. Mode selections are made by manually depressing one of 12 PRIME MODE pushbuttons and one of three SCNDR MODE pushbuttons on the FCC. Tactical use of the FCC occurs during operational sequences. An operational sequence is divided into three separate sequenced phases: (a) Missilized operations, (b) Denote operations, and (c) Prepare operations. All would be performed by FCC component input. Missilized operations are performed first, are time-consuming, and are performed on all missiles simultaneously. As each missile completes first phase operations, it is designated at the 1SQ condition of readiness.

At the completion of missilized operations, the FCC initiates denote operations on two of the 1SQ missiles. The denote operations are performed by launcher equipment to prepare the launch tubes for missile firing. After denote operations are completed, the missile enters into prepare operations which include missile readiness checks, missile battery activation, missile number check, guidance and fuze data transmission, read-in and echo check of guidance, and fuze data generation of the missile firing signal. The prepare phase is completed with the launch of the missiles.

As can be seen, FCC initiation, monitoring, and generation of sequenced commands compose a fairly exacting set of steps for specific actions on the part of FCC operators with other coordinated FCS and LCG actions. These sequenced operations allow for an excellent CBI application effort.

There are four control, display, and switching subsystems within the FCC: (a) the Control and Display Subsystem (CDSS), (b) Master Clock and Timing Subsystem (MCTSS), (c) Switching Subsystem (SWSS), and (d) Test Control and Display Subsystem (TCDSS).

a. Control and Display Subsystem

The CDSS provides to an operator an equipment interface that allows observation of equipment status events. It facilitates control, initiation, delay, stop or other actions with the FCS visual display provided on the Supervisor's Control Panel. This panel is partitioned into two sections: the status panel and the firing panel. Appropriate alarm processing is provided by the Hardware Alarm Detection Logic (HADL), which drives data for printing on the PTRSS. The Captain's Indicator Panel (CIP) will be located in the TRITRAFAC FCS laboratory and on-board personnel would inform the Captain of the operating mode of the FCS, status of all missiles, and SWS readiness states. A firing key assembly and missile emergency alarm are also provided.

Switches and actuator/indicators on the status panel are used to select the FCS mode of operation, to control configuration of DCC equipment, to monitor the operational status of SWS equipment, and to control and monitor the progress of missilized operations. On the firing panel, switches and actuator/indicators provide input/output for selection of firing mode, initiation and monitoring of denote and prepare sequences, and indication of when a missile is ready to fire. The Supervisor's Control Panel is a hinged masking panel with actuator/indicator modules mounted beneath the panel and protruding out through pierced holes in the panel. The firing key assembly consists of a shallow box-like structure containing a tactical firing key and a training firing key. The tactical firing key compartment is secured by a combination lock. Descriptive data on the missile emergency alarm was not available at the time of the study.

b. Master Clock and Timing Subsystem

The MCTSS provides a continuous time reference to FCS digital assemblies. The MCTSS consists of one master clock assembly and two timing assemblies. Both timing assemblies are in operation continuously. The time of day control and display panel is located in the upper left-center portion of the FCC. The panel includes two multiposition rotary switches, a keylock switch, two pushbutton switches, and a bank of thumbwheel switches. Time-of-day data is displayed on a group of decimal indicators.

c. Switching Subsystem

The SWSS consists of control logic and snapslide switches that perform necessary switching operations to complete or modify the intersystem interfaces. This subsystem also performs required switching for the desired configuration of signal path arrangements within the FCS. Three major types of switching are performed: Operational, mode, and configuration switching.

d. Test Control and Display Subsystem

The TCDSS provides control and display facilities for testing the FCS, the guidance system, the missile command sequencer, and for missile testing in conjunction with the MTRE. The primary operator/machine interface for the TCDSS is the Integrated Test Operating Panel (ITOP). The ITOP provides a variety of functions: selection of equipment to be tested and the particular test to be performed; control of the initiation and termination of tests; support of fire control tests, missile tests, and fuze set test modes on a one-at-a-time basis; simultaneous testing of multiple equipments, such as guidance systems and DRISS; and, operator monitoring of individual equipment test performance. Sequencing and analysis of equipment tests are provided by test programs operating in the DCC. Test results are indicated on either the ITOP or printed out

on the PTRSS. The ITOP is located on the extreme left-side center panel of the control console. Actuator/indicators devices (modules) are mounted under the ITOP panel plate. The panel is hinged at the top edge for maintenance accessibility.

The system printer (PRTSS) is located to the right of the ITOP. The PRTSS is a rack-side mounted device that can be pulled forward and out of the mounting panel for servicing and paper replenishment. The PRTSS will consist of a control panel, a circuit breaker, an illumination control, a paper take-up, printhead, and a power supply.

e. Power Control Panel

The power control panel is housed in an auxiliary wing structure to the left of the control console. It consists of switches and circuit breakers associated with the FCC.

f. Additional Equipment Assemblies

The power supply assembly, electronics assembly, log desk assembly, and interpost function assembly comprise the remaining components of the FCC. The log desk assembly protrudes forward from the ITOP and operating panel and contains telephone jacks and intercommunication switches. Both the power supply assembly and electronics assembly consist of housing, type 2 modules, and a slide mechanism. The type 2 module are vertically mounted on the slide mechanism.

2.5.3 Digital Computations Subsystem Group Description

The components considered for CBI within the Digital Computation Subsystem Group were the DCC Computer Programs, BPSS, DCPSS, COISS, CMSS, and KBDSS. This breakdown differs from Table 2-9 because of the desire to have interrelated instructional treatment of the topic content areas within the group. The KBDSS is in the Computer Peripherals Subsystem Group.

a. Basic Processor Subsystem and Data Communications Processor Subsystem

The Digital Computations Subsystem Group performs computational and control functions required by the FCS. The Digital Control Computer (DCC), composed of the BPSS and DCPSS, receives input data directly from other subsystems and indirectly from the guidance, launcher, and navigation systems. These data are used by the DCC computer programs to calculate guidance system data, missile flight data, command sequence data, and launch sequence control signals. Guidance system operational checks and verification checks are performed by the DCC. In all modes,

the DCC establishes the primary operator interface by means of control and status information displayed at the ITOP. Printout and keyboard data, assembled under DCC computer program control, are sent to relevant equipment in the Computer Peripheral Subsystem Group.

The BPSS is a microprogrammed, sequential processor with instructional look-ahead capability, consisting of a central processor unit (CPU) and main memory. Three interface networks connect the BPSS to the DCPSS, COISS, and CMSS. The DCPSS controls the transfer of data to and from its associated BPSS. Data transfer between the BPSS and other FCS equipment is directly controlled by the DCPSS. The DCPSS consists of a multiplexer controller unit (MXC) and a computer interface unit (CIU).

b. Computer Operator Interface Subsystem

The primary display and control interface between the DCC and the operator is achieved by the COISS. The COISS consists of an operator's panel and its supporting control logic, interface with the DCPSS through control and maintenance busses, and data paths to the DCSS and MDFSS.

c. Computer Maintenance Subsystem

CMSS provides support functions during DCC maintenance operations. Maintenance functions are performed by CMSS through manual input of the operator who observes DCC test program status. The CMSS operator panel contains a keyboard which allows selection and input of command words into the DCC and two computer maintenance logic sections to implement buffering, control, and formatting functions for data transmission to CPU, DCPSS, and MTFSS. Components consists of push-button keys, plasma display, illuminating actuator/indicators, and multicolored bulbs.

d. Keyboard and Display Subsystem

The KBDSS is included in this group because, by use of the KBDSS, the FCS operator inputs commands into a selected DCC and monitors computer status. The KBDSS keyboard is a time-shared, electromechanical device, containing push-button keys and indicators. Keys are used to enter inputs to the DCC. A display panel allows the DCC to communicate with the operator by these inputs and resulting output messages.

The KBDSS operator panel consists of a display panel and keyboard. The display panel is 222 dot-columns wide and 77 dot-rows high with a viewing area of 9.18 inches by 3.38 inches. The actual size of the glass panel is 11.8 inches wide, 5.2 inches high, and 1.3 inches deep. Displayed characters are neon red-orange in color. The panel is capable of displaying 8 lines of 32 characters per line with a total of 64 different characters. The DCC can display any of the 64 characters, but the operator is limited in his input. Characters from the DCC are less

bright than the operator input characters. The display panel also contains a movable cursor. Line selection function switches are located to the left of the display panel. The keyboard is located below the display panel. It consists of function switches and data entry switches.

2.5.4 CBI Selection Analysis for FCSU

It was determined that the FCC and the Digital Computations Subsystem Group offer the most cost-effective topic areas within the FCSU. The CBI hours were evenly divided between these two topic areas. The CBI strategies were developed within the 01 and 02 training levels with additional hours at the P1 and C1 levels. A fairly balanced mix of CBI hours by training level was achieved.

Only those equipments and instructional events within the training levels which were judged appropriate for CBI were included in the analysis. The description of instruction, resulting from the analysis, was drawn from prior FBM training, such as POSEIDON, and includes only those areas so supported. Training time estimates were derived from the Training Requirement Forms (TRF's) and were checked with contractors and instructors at current FBM schools. They are reasonable time allocations for CBI treatment within the proposed topic areas. As with the LCG discussed in paragraph 2.4, the CBI hours for the FCSU would supplement laboratory training but not replace tactical equipment experience. The simulation requirements determined for the FCC and the Digital Computations Subsystem Group address the various equipment characteristics, operator interactions, and subsystem interfaces. After these attributes were identified, CBI strategies were derived, and CBI terminal characteristics were determined.

2.5.5 Results of CBI Analysis

From the analysis, it was established that CBI could support all of the components covered in the instructional descriptions for the FCC and the Digital Computations Subsystem Group. Table 2-11 summarizes the CBI hours by training level and equipment. As shown, the CBI hours dedicated to the 01 and 02 training levels were approximately two-thirds of the total hours. Training at the P1 and C1 levels accounted for 10 hours. The largest number of CBI hours were identified in the CDSS and DCC Computer Programs topic areas.

The CBI simulation requirements, as shown in the Appendix, did not differ in display and response concepts from those discussed for the LCC in the 01 and 02 training levels. The amount of equipment simulation would be extensive but the operator stimuli would still be displays of indicators on the various panels contained on the actual tactical equipment. Audio message simulations are also required by the FCC. Deferred operator actions will also play a major role for the FCC operator at the 02 level. Finally, documentation would be closely tied to the CBI course materials to generate realistic operational scenarios.

Table 2-11

Summary of FCSU CBI Hours

FCSU LABORATORY EQUIPMENT	TRAINING LEVELS			
	01	02	P1	C1
CDSS	3	4	1	1
TCDSS	1	1		1
PTRSS	1		1	
TODSS	1			
DCC	1			
DCC Computer Program	2	4		1
BPSS			1	2
DCPSS			1	1
KBDSS	1			
COISS	1			
CMSS	1			
TOTAL HOURS	12	9	4	6

Note: See the appendix for details.

At the P1 and C1 training levels it was essential to combine the maintenance documentation with the CBI simulations of equipment malfunctions to provide troubleshooting training within a large number and many types of fault isolation conditions. As seen in the analysis tables, this CBI strategy is possible and establishes a training alternative to the use of actual tactical equipment. It also provides a wide range of opportunities for drill-and-practice exercises in fault recognition and isolation.

In all the training levels for FCSU CBI instruction, the need to provide for realistic interfaces exists. Whether between pieces of tactical equipment, test equipment to tactical equipment, subsystem to subsystem, or from all of these to the technical documentation, the interface with the trainee is of paramount consideration. These interfaces should be given thorough examination by CBI courseware developers.

Finally, the analysis entailed equipment by equipment instructional treatment. When the final CBI designs and objectives are formulated, this analysis, especially for the Digital Computations Subsystem Group, will also support a system level training treatment by functions, maintenance procedures, or operational modes. Whichever approach might be eventually adopted--equipment, subsystem, or system level training--CBI attributes and topics identified here will still be pertinent.

2.5.6 Recommendations for Additional CBI Treatment

There are additional CBI amenable topic areas remaining within the replacement training hours in the FCSU laboratory. It is also recommended that advanced or team training be considered if additional CBI hours are required. Both appear to be viable topic areas for CBI at this time. However, final TRIDENT documentation should be available before full determination of these hours.

2.6 Missile Control Center Laboratory

The Missile Control Center (MCC) provides training expertise in three areas: (a) FAST CRUISE fire control technician training, (b) launcher systems and control group missile technician training, and (c) missile system testing training. Each of the three have different training requirements, but all three are focused towards the same common goal: to provide system concepts and experiences to the trainee which the individual unit laboratories lack. It is within the MCC laboratory, which closely resembles the real TRIDENT MCC, that the trainee must be able to stand watch as if in the environment existing on board.

The FAST CRUISE concept of replacement training is a week-long laboratory simulated deployment cruise in which the trainees perform under actual operational conditions in all operator (O1, O2) and maintenance (P1, C1, and C2) levels. The simulated cruise includes only

conditions of readiness and operational modes which have been previously learned by the trainees. FAST CRUISE training is deemed highly valuable by SSBN training activities. Launcher systems and control group instruction is given concurrent to FAST CRUISE training and missile system testing.

The missile system testing portion of MCC training allows missile technicians to troubleshoot interface problems encountered during missile testing. While the training on actual Missile Test and Readiness Equipment (MTRE), both MK6 and 7, occurs in a separate unit laboratory, many missile testing interface problems develop from incorrect switching, improper hook-up, or inappropriate sequencing procedures. The MCC laboratory is utilized to provide training under these conditions. During missile system testing training, the trainee should recognize indications of a faulted interface, analyze the incorrect set-up conditions, and employ fault isolation procedures to correct the situation using authorized documentation. Actual "hands on" correction, however, is not deemed necessary to achieve the training aims of the missile system testing requirements of the MCC.

2.6.1 Equipment Selection

The equipment selection process, previously used for the LCG and FCSU laboratories, was slightly modified for the MCC laboratory for two reasons. First, the MCC will provide a reduced version of the FAST CRUISE employed for POSEIDON and further reduction seemed inadvisable to accomplish TRIDENT training goals. Second, since the launcher portion is concurrent training, it did not contribute substantially to the overload. This left only the remaining area, missile system testing, available for analysis.

When examined, missile system testing did not meet the criteria of being POSEIDON similar or supported by POSEIDON documentation because it represents a new training concept specifically developed for TRIDENT training. However, it did adhere quite well to several other criteria for CBI selection, as seen in Table 2-12. The concepts of fault recognition, analysis, and isolation were compatible with providing the opportunity to give the trainee an instructional flow which contained context coherance and completeness. Since "hands on" correction is not required, the missile system testing curriculum offered excellent CBI treatment possibilities. In addition, the large number of training hours provided a conducive situation in which CBI extracted hours could act as supplemental or remedial treatment to ensure attainment of all the stated training goals and ease the scheduling considerations for the remaining laboratory instruction.

Table 2-12

MCC Laboratory CBI Candidates by Ranking

LABORATORY MISSILE CONTROL CENTER (MCC)

REQUIREMENTS	CANDIDATES FOR SELECTION									
MINIMAL NUMBER OF EQUIPMENT PIECES IN COURSEWARE DEVELOPMENT	1	2	2	3	2	4	3	2		
CONTINUITY OF TRAINING CONTEXT	1	3	3	4	4	4	4	3		
DOCUMENTATION AVAILABILITY	3	4	3	3	4	4	2	2		
REINFORCEMENT OF CBI BY OTHER LAB INSTRUCTION	1	3	2	3	4	4	4	3		
SCHEDULING EASE OF CBI LESSONS	1	3	3	4	4	3	4	3		
PROVIDE FOR EFFECTIVE LAB SCHEDULING	1	3	2	3	2	2	4	3		
TOTAL WEIGHTING	8	18	15	20	20	21	21	16		
	A	B	C	D	E	F	G	H	I	J

A. CO/XO
B. FCS MK 98 MOD 0
C. OASSG
D. MSL & Fuze Set
E. MTRE
F. LCG
G. MSL System Test
H. SSO/SMO
I. ________
J. ________

RATING SCALE FOR SELECTION
1---No impact on requirement
2---Very little support of requirement
3---Some support of requirement
4---Able to fully support the requirement

2.6.2 Missile System Testing Description

The training covered in missile system testing is primarily concerned with the troubleshooting of interface problems and improper switching between pieces of equipment during the testing of the TRIDENT missiles. Two points stand out because of the interfacing of equipment and the training goals of recognition, analysis, and isolation: (a) a large number of equipment will be involved, and (b) documentation will be an essential training ingredient. Another consideration is that graphical and pictorial representations of the equipment do not require large amounts of dynamic animation.

The major emphasis of this block of laboratory training will be aimed at the switching and alignment of missile testing associated FBM equipment, both FCS and Ship's Systems, and the network interfacing of these equipments. Because of continuing equipment design changes, detailed configuration and functional documentation was not available at the time of the study. However, it was possible to identify a basic treatment of the equipment and the interfaces in the CBI analysis.

2.6.3 CBI Selection Analysis for MCC

The analysis for the MCC was focused upon the identification and treatment of slightly more than 25 hours of laboratory training time needed to relieve projected overload conditions. Having determined that missile system testing was the best subject for analysis, the study then established that this training resided within the P1-C1 levels. This training had not been delineated into segments of P1 or C1, but this did not hinder the analysis.

The major thrust of missile system testing instruction is to recognize improper equipment set-up which would adversely influence the performance of various tests performed upon TRIDENT missiles. The trainee will be required to establish a concept of the total FBM system so that when called upon to initiate tests and interpret test results, distinction can be made between MTRE-caused discrepancies, missile originating malfunctions, and other interface problems. The trainee also will be able to initiate corrective action to successfully complete the testing procedures.

2.6.4 Results of CBI Analysis

Missile system testing instruction can support 25.25 CBI hours as shown in Table 2-13. In addition, the CBI treatment can provide greater instructional impact than the originally conceived missile system testing training. By representing several system components simultaneously, CBI instruction can facilitate the rapid acquisition of a systems orientation. This might be done by split screen or dual displays, for example, to provide views of several panels. This feature of CBI adds a powerful tool in that the trainee could require less instruction time and less physical moving from one piece of equipment to another as he troubleshoots problems. By simultaneously viewing the various pieces of equipment on the CBI terminal, the trainee actually travels instantaneously throughout the SWS equipment set-up without having to leave his seat. While being beneficial to the acquisition of training level skills, this unique feature of CBI requires a large development effort to ensure properly sequenced displays and an interactive tutorial mode of instructional strategy.

2.6.5 Recommendations for Additional CBI Treatment

Missile system testing appears to be the only major CBI topic area in replacement training. However, CBI treatment for missile system testing instruction may allow an alternative in the area of team training. The alternative to meet unexpected overloads would be utilization of the already developed CBI missile system testing courseware to either bring new students up to a uniform level of intersubsystem troubleshooting skills or to train crewmembers in upgraded Type Commander operational tests. In this way additional development costs would be minimal.

2.7 CBI Terminal Characteristics

In paragraphs 2.4, 2.5, and 2.6, CBI simulation strategies which reflected stimulus display and response input characteristics of a CBI terminal were described. For example, if CBI is to be used to simulate the LCC in the LCG laboratory at the 01 training level, then the LCC panels must be displayed with good resolution graphics or pictures (see Table 2-6). Furthermore, since these panels have color indicators, the colors or an indication of color and color change must be provided, as well as the symbol display seen on the panel. In addition, simulation of the LCC requires a keyboard or some response device to allow operator actions during the CBI simulation.

The suggested terminal characteristics for CBI simulation in the earlier sections, therefore, provide a base from which to draw the CBI system media requirements. In the remainder of this section, these terminal characteristics will be reviewed; related to stimulus and response simulation needs of the training described in paragraphs 2.4, 2.5, and 2.6; and related to the CBI system specification and candidate evaluation in section 3.

Table 2-13

MCC Hours Selected for CBI in Missile Systems Testing

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
P1-C1 25.25 Hours	1.1 Perform interface troubleshooting on MCC/MC equipments in accordance with authorized documentation	2.1 Recognize indications of equipment incorrectly set-up (wrong switching) during interfacing of the required number and composition of tactical equipment required during relevant testing modes in accordance with authorized documentation. This instruction focuses at missile tests and all associated support equipments/subsystems of the missile, guidance, fire control, launcher, and ship support system. ITOP would serve as the coordination point for the conducting of inter-subsystem testing.	3.1 Equipment to Operator a. Actuator/indicators b. Illumination of (a) c. Key actuator switches d. Thumbwheel switches e. Multi-position rotary switches f. Printer readouts g. Graphic and pictoral representation of equipment and procedures h. Network displays of cabling with pieces of equipment interconnected i. Displays for coordination	4.1 Equipment Simulation a. Simulate the following pieces of equipment: (1) FC console (2) MTRE Mk6 and 7 (3) TMPS (4) ITOP (5) MMSC panel (6) FC switchboard (7) Relevant Power Distribution Panels (PDPs) (8) Ship's junction box assembly (9) Missile junction box (MJB) (10) Weapons power distribution switches	High Resolution, Dynamic Graphics, Pictorial Representation, color or color indication capability
				b. Provide for at least 4 color on actuators/indicators	Color or color indication capability
				c. Provide for a range of alphanumeric values	Fast response and programmable symbols
			3.2 Operator to Equipment a. Analysis of 3.1 (a) through (i)	4.2 Operator Interface a. Analysis of 4.1	
			3.3 Equipment to Equipment a. TMPS to MTRE Mk 7 and FCS b. ITOP c. FC switchboard to FCS d. PDP to MTRE Mk 7, TMPS, and FCS e. Ship's junction box to FCS f. MJB to FCS g. Navigation to FCS h. MMSC	4.3 Equipment-to-Equipment Simulation a. Provide for proper equipment sequencing b. Ensure coordination of equipment c. Ensure compatibility with documentation	Terminal aids to programming and editing
		2.2 Analysis of incorrect interface equipment setup and procedures in accordance with authorized documentation during relevant testing modes	3.4 Equipment to Operator a. Same as 3.1 with insertion of specific interface problems	4.4 Equipment Simulation a. Same as 4.1 with insertion of specific interface problems	Same as 2.1
			3.5 Operator to Equipment a. Same as 3.3 with insertion of specific interface problems	4.5 Operator Interface a. Same as 4.1 with insertion of specific interface problems	Same as 2.1
			3.6 Equipment to Equipment a. Same as 3.3 with insertion of specific interface problems	4.6 Equipment-to-Equipment Simulation a. Same as 4.3 with insertion of specific interface problems	Same as 2.1
		2.3 Isolate those interface and equipment incorrect setup problems and procedures by developing possible troubleshooting strategy(s) to rectify incorrect situations in accordance with authorized documentation during instructional situations	3.7 Equipment to Operator a. Same as 3.4 coordinated to appropriate documentation	4.7 Equipment Simulation a. Same as 4.4 coordinated to appropriate documentation	Same as 2.1
			3.8 Operator to Equipment a. Same as 3.5	4.8 Operator Interface a. Same as 4.5	Same as 2.1
			3.9 Equipment to Equipment a. Same as 3.6 coordinated to appropriate documentation	4.9 Equipment-to-Equipment Simulation a. Same as 4.6 coordinated to appropriate documentation	Same as 2.1

2.7.1 Types of Terminal Characteristics

Functionally, CBI terminal characteristics can be classified as: (a) student terminal functions, (b) courseware development terminal functions, and (c) management terminal functions.

The student terminal provides the actual man/machine interface for the learning process. The interface characteristics of the student terminal are the prime concern of this section. The trend in CBI terminals is to provide a multiplicity of media forms for communication from and to terminals, especially for simulation strategies.

The design of a course which is to be presented through CBI involves analysis and planning to maximize the use of the media provided for simulation. Typical ratios published for the labor which must be expended in CBI authoring range from 100 to 500 hours per CBI hour developed. To facilitate CBI authoring, consideration must be given to the availability of hardware or software features which have the purpose of ease in development of CBI material. These features usually take the form of options to the student terminal. The user of this capability will generally have more expertise in instructional technology than computer technology. Therefore, the courseware development function should also be as independent of computer system knowledge as is possible.

Although the student's primary training interface will be with computer systems, there is still need for providing for human monitoring and counseling within the learning process. One technique which can aid in human monitoring is through use of a management terminal. Such a terminal receives on-line student performance parameters from a number of active student terminals. From this terminal, a supervisor can make judgments on overall progress and determine need for immediate student counseling on problems monitored. Such judgments will be made by TRITRAFAC laboratory instructors.

2.7.2 Terminal Requirements for SWS Laboratories

Terminal characteristics for SWS laboratories at TRITRAFAC were analyzed by display and response simulation requirements. In addition to the student interface needs, courseware development and instructor management were taken into account. Throughout the tables in paragraphs 2.4, 2.5, and 2.6, and the appendix, which relates laboratory training to CBI simulation strategies and terminal items, the following displays and response capabilities are noted.

2.7.2.1 Display Requirements

Requirements for a display which provides the primary media for computer output to the student have been established. The display must provide the most efficient interactive interface between the student and computer. It should display the student's input for his verification

before computer entry, representations of equipment panels, maintenance modules and other components, and alphanumeric text. The technical method of system update for this display (matrix or rastor) is not critical to the training requirements.

Although not considered critical, it is desirable to provide capability for an overlay of photographic material on computer-generated material for high fidelity representations. This capability can be provided through automatic rear projection of an image onto a transparent electronically controlled display screen. A capability for computer-generated graphics, as well as alphanumerics, is required in order to simulate console panels which may have real-time changes or motion involved. Therefore, it is also required that these graphics be dynamic.

The display must have high resolution and low flicker. A bit pattern of 512 x 512 for the resolution and 60 frames per second for any picture frame refresh rate should be acceptable.

The display must have color capability for high fidelity simulation. Many of the equipment panels have multicolor indicators. For example, color representations are noted in simulations of the Basic Processor Subsystem (C1 level), the Launcher Control Console (O1, O2, P1, and C1 levels), and the Printer Subsystem (O1 and P1 levels) in the tables referred to above. Color can also be used for emphasis on critical portions of the display. The extent of the color control required is a function of the CBI systems available, however.

Assuming that all other required or desired characteristics are met by some means, additional features provided by high fidelity representation are not a requirement. Specifically, it is not a requirement that a photographic quality moving picture be projected on the screen. However, the use of video is one method for providing the other required or desired display characteristics such as motion and color. Likewise, front panel mock-ups are not necessary, although they would satisfy the simulation requirements.

There is no requirement established for hardcopy of the computer displays to the student. However, the functional requirements of a courseware development terminal include a firm requirement for hardcopy of the courseware material for documentation purposes. It is also desirable for instructors to receive hardcopy summaries of student progress. An alphanumeric hardcopy presentation should be adequate and no requirement for graphic copy is expected, although it might aid in documentation of graphic displays used during simulation. The quality of the copy is not critical and, therefore, nontypewriter devices which have a low noise level would suffice.

The technology of CBI has advanced to the point of the possibility of voice interface between the student and the terminal. The computer can

either control the output of prerecorded messages or voice output can be computer generated and synthesized with recognizable fidelity. A limited set of voice commands are also possible for input to the terminal. Presently, the use of these commands requires a computer learning process for each new voice introduced to the terminal. However, no simulation requirement has been established for voice input or output and, therefore, it has been eliminated from consideration. Text displays should be adequate to simulate the voice messages during operator training.

2.7.2.2 Response Requirements

A keyboard for alphanumeric input is required for both courseware development and student responses. The standard ASCII key set is assumed sufficient with only upper case as an absolute requirement. Lower case ASCII would be desirable. A special numeric cluster in addition to the numeric capability of the ASCII keys is useful for work involving heavy arithmetic input, but is not a requirement. Functional keys would enhance the capability for student responses during simulations and during courseware development but are not necessary.

Another keyboard option conceptually available on a CBI system is flexible key sets. Hardware and software designs exist for easy insertion of new key caps and new computer interpretation of the key activations. Another possibility is the complete substitution of a keyboard module with alternate key sets. Another capability for a changeable key set would be the use of a plasma panel with a touch pattern forming the key set. With this approach, the figures representing the key press can be altered by the touch of a button. A review of the TRIDENT simulation requirements disclosed no absolute need for any key set other than standard ASCII, although special programmable symbols which are associated with keys in some manner as described above are desirable.

Touch panel and stylus response devices are discussed here as a unit to stress their overlapping possibilities. The classic touch panel involves dividing a display screen into a relatively coarse grid. A finger touch to the panel is sensed by the terminal and indications of a specific area touched within the grid are sent to the computer. Typical resolutions afforded in sensing the area touched might be stated as one area selected out of a total available of 16 to 64. A stylus usually involves an active element, such as a pen, to be held in the hand. The stylus is pointed at a precise spot on the screen and an accurate measure of the coordinates are sent to the computer. The resolution is near or equal to the resolution of the display itself.

A capability for accurate positional student input on the display screen is a requirement for TRIDENT simulation. The accuracy requirement does not dictate stylus level accuracy. It appears, however, that a stylus can adequately provide the function. If a stylus is used, it should be a requirement that the stylus be applied directly to the

display screen with no interference to the brilliance of the display. It is not critical that the system be capable of accepting a passive pointing element such as a finger or nonactive pen, although this accuracy level would suffice.

2.7.2.3 System Level Associated Requirements

Several characteristics associated with terminals, which are not part of the media requirements per se and which may depend upon other computing system components, are identified here in relation to TRIDENT simulations to provide a more complete set of requirements.

Response time is defined as the average time required for the CBI terminal to begin a detectable response to a student action. Fast response time is required for the simulations in order to obtain real-time fidelity, decrease lost time in training, and lessen distractions in student concentration. A range of response time acceptability has been established at a delay from 0.1 to 0.2 seconds.

System modularity is a requirement. The CBI system must be capable of convenient expansion to accommodate an increase in student contact hours of up to 100% of the original requirements. This increase may be the result of either an increase in the number of students being trained or an increase in the CBI curriculum made available. The need for modularity must be reflected in capability for expansion in number of terminals, capacity of central or terminal processor memory, capacity of central or terminal random access bulk storage, capacity for data communications, or any other workload sensitive functions.

A courseware language which relieves the training personnel from the requirement for developing computer programming expertise is a requirement. This requirement is also based on the need for easing the workload involved with generation of the many courses which will be required to reduce the TRIDENT laboratory overload through CBI implementation. Of special significance is the support needed for developing both static and dynamic graphics.

The degree of schedule control needed within the TRIDENT training program places a firm requirement on high reliability of terminals and associated components. Reliability considerations are dependent on CBI system design. Terminal availability may be assured by having back-up terminals on-site.

Finally, in order to allow instructors the capability for evaluation of students as soon as they finish a CBI lesson, it will be necessary to summarize and display student data. This data will also be needed for CBI curriculum evaluation, especially during the courseware development periods.

2.7.3 Summary of Terminal Characteristic Requirements

The laboratory training analysis results from paragraphs 2.4, 2.5, and 2.6 were compared to state-of-the-art CBI terminal characteristics to determine the suitability and/or the requirement of these characteristics for TRIDENT training. In section 3, several CBI system candidates are evaluated in terms of CBI characteristics that are required for TRIDENT training. The methodology for the evaluation involves principles of the Kepner-Tregoe Decision Analysis Model. Within this model, the CBI terminal characteristics are classified as "musts" and "wants." The "musts" identify terminal characteristics essential to achieve the simulation of SWS tactical training equipment, while the "wants" establish terminal characteristics that enhance the simulation. The CBI terminal characteristics previously identified are summarized in Table 2-14 as "musts" and "wants."

2.8 Terminal Numbers

The number of terminals required is based on two factors: (a) the amount of terminal utilization and (b) how that use can be scheduled. There are three CBI terminal user types for SWS training. These are: (a) students, (b) instructors, and (c) instructional developers. After determination of the amount of utilization that can be expected for each of the three user types, scheduling of the activities will be taken into account.

2.8.1 Student Utilization

The basic unit of utilization is terminal contact time required over some period of time. Since the laboratory utilization was projected in hours per year, CBI terminal utilization followed the same measure. Student utilization in contact hours per year was determined separately for each laboratory. The calculations are shown in Table 2-15. Information in the first three columns--CBI hours projected, classes per year, and contact time--was used to calculate the minimal number of terminals required and the percent utilization of 12 terminals.

The number of terminals required to support CBI curriculum in a laboratory was determined by:

$$\text{Number of Terminals} = \frac{\text{Contact Time in Hours per Year}}{\text{2,526 Hours per Terminal per Year}}$$

Table 2-14

Summary of CBI Characteristics for TRIDENT SWS Terminals

REQUIREMENTS	MUST	WANT
DISPLAY REQUIREMENTS		
CRT OR PLASMA	X	
REAR PROJECTION (OVERLAY)		X
GRAPHICS	X	
DYNAMIC GRAPHICS	X	
HIGH RESOLUTION (512 x 512)	X	
LOW FLICKER 60 FRAMES/SEC	X	
COLOR	X	
HARDCOPY (NOT FOR STUDENTS)	X	
RESPONSE REQUIREMENTS		
KEYBOARD	X	
STANDARD ASCII	X	
NUMERIC CLUSTER		X
STUDENT FUNCTION KEYS		X
EDIT FUNCTIONS FOR AUTHORING		X
FLEXIBLE KEY SETS		X
TOUCH PANEL OR STYLUS	X	
PASSIVE ELEMENT		X
OVERLAID ON DISPLAY	X	
HIGH RESOLUTION		X
AREA SELECTION RESOLUTION	X	
SYSTEM ASSOCIATED REQUIREMENTS		
FAST RESPONSE (0.1 to 0.2 SEC)	X	
MODULARITY FOR GROWTH	X	
COURSE DEVELOPMENT LANGUAGE	X	
HIGH RELIABILITY	X	
RESPONSE DATA COLLECTION	X	

Table 2-15

Student Terminal Utilization

LABORATORY	CBI HOURS PROJECTED	CLASSES PER YEAR	CONTACT TIME IN HOURS	NUMBER OF TERMINALS REQUIRED	TWELVE TERMINAL UTILIZATION
FCSU	31	12.66	4,710	1.9	16%
LCG	8	26.80	2,573	1.0	8.5%
MCC	25.25	26.80	8,120	3.2	29%
TOTAL	64.25		15,403	6.1	53.5%

It has been shown in paragraphs 2.2 and 2.3 that there are 2,526 hours of training time available in each laboratory. The same amount has been assumed for terminals, allowing for worst case scheduling and maintenance. Contact time was calculated by:

Contact Time per Year	=	Number CBI Hours Projected	X	Classes Per Year	X	12 Students Per Class

The results of these calculations are that 1.9, 1.0, and 3.2 terminals are required for the FCSU, LCG, and MCC laboratories, respectively. These numbers assume perfect scheduling of the terminals, but additional time to allow for nonuse periods does not impact them significantly. Further, as explained in paragraph 2.8.4, 12 terminals are recommended to allow for a complete replacement class at one time and this provides extra hours. The utilization of 12 terminals by students would be around 53.5% of total time available.

2.8.2 Instructor Utilization

The primary use by instructors will be during the time of student use. Reports on student progress will probably be generated off-line and not at the terminals. Therefore, no significant amount of instructor use is seen.

2.8.3 Instructional Development Utilization

Two terminal uses by personnel responsible for CBI curriculum are seen. The first of these is the development of the CBI material and includes terminal contact time for authoring, debugging, editing, and evaluation. The second use is maintenance of CBI curriculum. Table 2-16 shows the number of terminals required and the percent utilization of 12 terminals, by laboratory, for both development and maintenance.

Table 2-16

Development and Maintenance Terminal Utilization

LABORATORY	CBI HOURS PROJECTED	TERMINAL FUNCTION	CONTACT TIME IN HOURS	NUMBER OF TERMINALS REQUIRED	TWELVE TERMINAL UTILIZATION
FCSU	31	DEVELOPMENT	6,200	2.5	20.5%
		MAINTENANCE	620	.25	.21%
LCG	8	DEVELOPMENT	1,600	.6	5.3%
		MAINTENANCE	160	.06	.05%
MCC	25.25	DEVELOPMENT	5,050	2.0	16.7%
		MAINTENANCE	505	.2	.17%
TOTAL	64.25	DEVELOPMENT	12,850	5.1	42.4%
		MAINTENANCE	1,285	.51	4.2%

Terminal contact time for the development function is based on an index of 200 hours of author contact time per hour of CBI developed. The 200 hours was determined by surveying military CBI users as explained in section 3. The 200-hour figure is actually a liberal estimate of contact time. It should not be expected that all of this will be at the terminal since some time is also spent in desktop analysis and paper work. However, the 200-hour figure also allows for formative evaluations with a few students. The contact time column for the development function, therefore, reflects a multiplier of 200 hours for each hour of CBI time developed. The number of terminals for the development function was determined in the same manner as for student utilization. That is, each terminal is considered to have 2,526 hours available and this number was divided into the contact time to arrive at a terminal number. Likewise, the 12 terminal percent utilization is based on 12 terminals available at 2,526 hours each. It should be noted that, while a total of 42.4% terminal time utilization is projected for the development function, these hours occur before steady state, and are actually phased over three years instead of one year, as shown in section 3, Figure 3-4. This means that the 12 terminal percent utilization is actually going to be much lower, probably less than 20% at peak, and require no more than two terminals at a time before maximum student usage.

The number of contact hours for maintenance is based on a projection of four minor changes per year required for each CBI hour developed. Five hours of contact time for each minor change are expected. The minor changes can be expected from peak steady state TRITRAFAC student volume through the life of the system. More major changes can be expected for a short period before steady state occurs, but the number of terminals, 12, should more than adequately provide the required time. On this basis, only about .5 terminals are seen necessary for maintenance of CBI curriculum or 4.2% of the total available terminal time.

2.8.4 Scheduling Factors

Beyond the computation of expected terminal contact hours is another factor of paramount performance; that is, the scheduling of terminal time. CBI must fit into total laboratory utilization and the scheduling of laboratories. CBI, for these reasons, should be considered as a laboratory resource. One important factor in scheduling is that classes are run in 12-man groups. Thus, if only four, six or eight terminals are available, the student scheduling must be staggered to complete the CBI time. This could cause delays in starting classes or laboratories as well as reducing total scheduling flexibility. It is, therefore, desirable to schedule all the students in a class to start at the same time on CBI, and this requires 12 terminals. Laboratory groups are actually run in four-man groups, however, and if CBI occurs at the middle of laboratory time, then scheduling might allow for staggering the four-man groups between CBI and laboratories. Three laboratories could be stagger-scheduled on this basis with 12 terminals.

Taking scheduling into account, as well as projected utilization, 12 terminals are required. These can be expected to have a student use of about 53.5% and curriculum maintenance use of about 4.2%. Twelve terminals, therefore, allows expansion of CBI curriculum for laboratory overloads, if necessary. One additional terminal should be acquired as a spare, however, in the situation where one of the 12 is down for repairs. A total of 13 terminals is recommended for SWS training at TRITRAFAC with 64.25 hours of CBI curriculum.

SECTION 3. PHASE II: CONFIGURATION DESIGN

3.1 Overview

The major purpose of this section is to provide TRIDENT SWS training managers with information to facilitate decision making. The first part of the section addresses the question: what are the criteria for selecting a CBI computing system for SWS laboratory training? Two basic criteria were defined for the selection process: (a) the computing system must fulfill the training requirements, and (b) the computing system must be cost competitive with other systems meeting the requirements.

Paragraph 3.2 describes the methodology used to evaluate the CBI systems which are currently available. The purpose of the evaluation is not to allow a decision as to which systems are generally better than others, but to identify which systems meet the two selection criteria. Paragraphs 3.3, 3.4, and 3.5 detail the evaluation process. It should be noted that, as is the case with many management tools for decision making, the methodology used here is not absolute nor is it infallible. However, as summarized in paragraph 3.6, sufficient information was obtained to select the CBI systems which could fulfill the training requirements identified in section 2. Cost comparisons for these candidates are described in section 4.

The next part of this section describes the personnel configurations associated with the CBI system configurations identified earlier. The personnel types required for each configuration are divided into two categories that represent the two major components of a CBI system--hardware/software and courseware. These two categories are subdivided into initial implementation requirements and recurring support requirements.

Paragraph 3.7 identifies the types and number of personnel necessary to install and maintain the hardware/software for each CBI system alternative. Paragraph 3.8 specifies the personnel mix and number of people required to develop the CBI courseware and paragraph 3.9 discusses the level of effort required to maintain the CBI courseware over the system life-cycle.

Finally, this section addresses the effort which is required to successfully incorporate CBI into the FBM Training System. Regardless of the CBI system selected from the three configurations identified, certain baseline activities are required to implement CBI. Of most importance are the roles, procedures, and specifications for CBI courseware development and maintenance. These must be included in the FBM Training System documentation to ensure adequate management control.

Paragraph 3.10 provides an overview of the current FBM Training System documentation. Paragraph 3.11 discusses the current roles and procedures within the SSBN Weapon System Training Materials Program. Working within the framework of this established program, paragraphs 3.12 and 3.13 address the roles and procedures required to develop and maintain CBI courseware. Paragraph 3.14 discusses current documentation modifications required to incorporate CBI into FBM training.

3.2 Computing System Evaluation Methodology

The methodology used to evaluate CBI systems for TRIDENT training is based on principles of the Kepner-Tregoe Decision Analysis Model. This model provides a systematic approach for identifying the most suitable candidates to satisfy the functional requirements from a range of alternatives. The model involves a three-step process:

a. The classification of functional requirements into "musts" and "wants." Musts define the essential requirements and set the limits which are acceptable. Wants identify the desirable requirements in terms of relative advantages and disadvantages.

b. The determination of which alternatives can meet the "musts."

c. The rating of the candidates in terms of satisfying the "wants."

In this application of the model, the range of alternatives are the CBI computing systems which are currently available, the functional requirements are the computing system characteristics which are necessary for equipment training simulations with CBI, and the suitable candidates are those systems that meet the training requirements in a cost competitive manner. The following sections describe the three steps in the model in terms of evaluating CBI systems for TRIDENT training.

3.2.1 Classification of Functional Requirements

The functional requirements were identified in the CBI configuration training analysis. Table 2-14 in section 2 summarizes the terminal display and response characteristics and system associated requirements in terms of "musts" and "wants." From this preliminary breakdown of functional requirements, the "musts" are further categorized as either absolute or relative musts. Paragraph 3.3 defines the absolute musts to be used in Step b.

3.2.2 Evaluation of Alternatives

The characteristics of each CBI computing system alternative are evaluated against the list of absolute musts on a YES/NO basis. If a system does not satisfy all of the absolute musts, it receives a NO GO

status and is dropped from the list of potential CBI candidates. Paragraph 3.4 evaluates the 11 CBI systems currently available against the list of absolute musts.

3.2.3 Rating of Candidates

Normally the systems that received a GO status in Step b would be rated against a list of "wants" in this step. However, rating the CBI computing system candidates in terms of relative hardware/software advantages and disadvantages would provide no additional information in the evaluation process. If the CBI system candidate can fulfill the training requirements in terms of absolute musts, cost factors are the only relevant selection criteria. Paragraph 3.5 summarizes the GO/NO GO status of the 11 systems and discusses the cost considerations for the GO system candidates.

3.3 Computing System Musts

In order to eliminate from consideration those CBI computing systems which are inappropriate for TRIDENT training, a list of absolute must requirements was established. Absolute musts are those CBI computing system requirements which must be satisfied on a YES or NO basis to fulfill SWS laboratory training simulation. During the training analysis, described in section 2, the terminal display and response characteristics and system associated requirements were identified as "musts" and "wants." The "musts" summarized in Table 2-14 in section 2 were the basis for establishing the list of absolute must requirements. Those musts not defined as absolute in the following paragraphs were categorized as relative musts and were not used in the evaluation of CBI system alternatives.

3.3.1 Display Absolute Musts

The display for CBI training simulations requires representations of panels, switches, indicators, and other equipment characteristics. For TRIDENT SWS training, the representations must also be dynamic. That is, motion must be provided to represent changes in switch settings, indicators, or other equipment/system status changes. Such a capability is usually provided with dynamic graphics. Another way is to display a pictorial presentation, such as is done with a rear view projection screen overlay, in combination with a dynamic graphics. The pictorial and graphics capability is higher fidelity but not a necessity. The least required on a YES/NO basis is dynamic graphics.

Representation of color for SWS training is important because of the many color indications of equipment and system status. The color variations cannot be simulated well by simply writing a color name on a display because of the several variations of one primary color, such as red, for one indicator. Real color display capability is required for

many situations. Although there are degrees of color display capability in CBI systems, "color" has been established as a YES/NO requirement to provide a baseline for a GO/NO GO decision. "Color" can be provided on current CBI systems through color graphics, slide or microfiche projection, and videotape.

The final display requirement which may be viewed on a YES/NO basis is hardcopy capability. This is required by CBI curriculum authors and managers for documentation and control. The system should provide at least hardcopy of program listings.

3.2.2 Response Absolute Musts

Two student response capabilities are required on a YES or NO basis. The first is a full alphanumeric keyboard. Although special keys for author editing and student functions are desirable, they are difficult to specify without linking them to specific systems and, therefore, are not included as an absoulte must. All CBI systems do have full alphanumeric keyboards as standard response devices.

A more distinctive response requirement is for a touch panel or stylus which can be used to point to a graphic or pictorial representation of equipment on the screen. This capability provides a major, interactive simulation feature of a CBI system. The amount and type of operator and maintenance training in the SWS laboratories dictates that the feature be included on a YES/NO basis.

3.3.3 System Associated Absolute Musts

Several computing system characteristics which aid in ensuring successful CBI simulation training for SWS laboratories are defined as absolute musts. First, a fast system response time is required to provide a "real time" setting to students. Fast response time is defined here as less than 0.2 seconds average time to begin a new display after entry of a student response. The other two absolute musts are related to CBI curriculum development and management. They are a course development language and the capability to collect and analyze response data.

3.3.4 Summary of Absolute Musts

The following list is a summary of the absolute musts in the order in which they will be discussed in paragraph 3.4:

a. Dynamic Graphics

b. Color Representation

c. Hardcopy

d. Keyboard

e. Touch Panel or Stylus

f. Fast Response

g. Author Language

h. Response Collection/Analysis

3.4 Computing System Alternatives

The CBI computing system alternatives for consideration in SWS laboratory training were drawn only from those in existence now. That is, it was not considered desirable, or necessary, to develop a new system for use in TRITRAFAC. Eleven systems were selected on a preliminary basis for comparison against the list of absolute musts defined in paragraph 3.3. The systems were selected on several bases. First, some are widely known, state-of-the-art, systems. Others were selected for consideration either because they were suggested by Navy activities who had some knowledge of the system, such as the Honeywell system at the Navy installation in Millington, Tennessee, or because they appeared to be economical CBI systems. Not all possible systems in the world of CBI were considered, but the list to be evaluated represents that world well. In the following sections each of the 11 alternatives will be described according to the list of absolute musts in paragraph 3.3.4.

3.4.1 Hewlett-Packard 2000/3000

The Hewlett-Packard Company markets a minicomputer system for CBI based on their Model 2000/3000 BASIC timesharing systems. Up to 32 terminals can be active at any given time with the dual processor configuration.

a. Dynamic Graphics

The terminals offered in association with CBI are alphanumeric only. However, graphics terminals built by Tektronix are available with a software package which could be interfaced to the CBI software.

b. Color Representation

No capability is provided for display of color either on a CRT or as an adjunct display.

c. Hardcopy

Using either the Course Writing Facility (CWF) or Instructional Dialogue Facility (IDF) in conjunction with a hardcopy terminal (as opposed to a CRT), it is possible for the author to receive printed paper versions of courses, both as program listings and as student displays.

d. Keyboard

All required keyboard characteristics are satisfied.

e. Touch Panel or Stylus

No position indicator capability, either by touch or stylus, is available.

f. Fast Response

With nongraphic terminals which are hardwired (no phone lines), system response is apparently no problem. However, with 13 graphics terminals on one processor (one processor is required for 16 terminals), "real time" display and processing might be a problem. Since several other absolute musts have not been met by the system, no attempt was made to verify expected system response time with Hewlett-Packard.

g. Author Language

Hewlett-Packard provides excellent CBI authoring capabilities in two software packages. CWF is a CBI programming capability compatible with IBM's COURSEWRITER III. The second package, IDF, enables authors to conversationally generate CBI materials. The conversational author mode requires little experience to become an effective user.

h. Response Collection/Analysis

By using IDF and the Instructional Management Facility (IMF), it is possible to record student responses, analyze the data, and generate reports as required.

3.4.2 Navy CMI System at Millington

The Navy has recently acquired a large scale computing system built by Honeywell for use in computer-managed instruction (CMI). An option on that system is for terminals and software to support direct CBI instruction.

a. Dynamic Graphics

The terminals offered by Honeywell are alphanumeric CRTs. Dynamic graphics capability is not provided.

b. Color Representation

No capability is provided to display colors, either as graphics or pictorially.

c. Hardcopy

Hardcopy of programs is possible.

d. Keyboard

A standard alphanumeric keyboard is provided with the CBI terminal option.

e. Touch Panel or Stylus

No position indicator capability, either by touch or stylus, is available.

f. Fast Response

It is difficult to assess the response time characteristics of this system if all display requirements were met. However, given the amount of CMI and other functions on the system, as well as the general purpose nature, it is unlikely that less than 0.2 seconds average time could be met.

g. Author Language

A CBI language named PLANET is available. However, language support for graphics and other TRIDENT simulation authoring requirements is not available.

h. Response Collection/Analysis

The Navy CMI system will adequately support response data collection and analysis through its existing software resources.

3.4.3 Commercial Time-sharing Systems

During the study, several suggestions were made that commercial time-sharing systems located in the Northwest should be analyzed in order to reduce the line costs of a network system selection. Specific systems were not studied, but general characteristics of such commercial systems which lease time are included for completeness.

a. Dynamic Graphics

Not all of this type of timesharing system have dynamic graphic displays available. Some do, however, and would be possible to use for TRIDENT SWS training.

b. Color Representation

Commercial timesharing systems do not offer color graphics or CBI associated media displays such as microfiche, slides, or videotape which can be in color.

c. Hardcopy

Listings of programs are available in hardcopy through most of these services.

d. Keyboard

Standard alphanumeric keyboards are available.

e. Touch Panel or Stylus

The business and scientific application-oriented timesharing systems do not usually provide the capability of positional indicators.

f. Fast Response

Given the necessarily general purpose nature of commercial timesharing systems and the sometimes heavy computational processing load, it is unlikely that an average response under 0.2 seconds could be achieved.

g. Author Language

CBI author languages are available on some large-scale timesharing systems and it is assumed that such a system could be found in the Northwest area. However, two such systems, the IBM 360 COURSEWRITER and UNIVAC ASET, are directly addressed later in this section.

h. Response Collection/Analysis

Those systems with authoring language capability would also have software and storage facilities for response data collection and analysis.

3.4.4 UNIVAC

CBI software and hardware support is offered by UNIVAC on several systems. The Marines, for example, use such a system based on a UNIVAC 1108 and operated by the Navy, to provide CBI at several bases in Southern California. Since the same or similar system might be made available to TRITRAFAC it was included for study.

a. Dynamic Graphics

Dynamic graphic terminals are supported with the UNIVAC systems although not directly under the CBI author language.

b. Color Representation

No color capability is available for representing panel components such as indicator/switches.

c. Hardcopy

Hardcopy of CBI lessons is available.

d. Keyboard

Standard alphanumeric keyboards are available on the terminals.

e. Touch Panel or Stylus

Positional indicators are not available.

f. Fast Response

The UNIVAC 1108 system is an extremely high capacity processing machine in larger configurations. It is possible that even with a general purpose operating system fast responses could be achieved under the right conditions. However, if the system were being used for large computational tasks at the same time as CBI, the response times would be greater than required. The system would therefore have to allow CBI a priority over other tasks. It was not determined during the study whether this would be acceptable to Navy activities operating UNIVAC systems capable of CBI since sufficient questions concerning display and response requirements had already been raised to eliminate the systems from cost considerations.

g. Author Language

UNIVAC provides a CBI authoring system which is well documented and relatively easy to use.

h. Response Collection/Analysis

Response data collection is made possible along with appropriate file management, statistical routines, and report generation capability.

3.4.5 IBM COURSEWRITER III

The IBM COURSEWRITER III CBI system is a combination of specially developed CBI software and terminals operating on 360 series machines. The COURSEWRITER capability was studied since the Navy, as well as other installations in the Northwest, has 360 systems in service.

a. Dynamic Graphics

The COURSEWRITER III software and terminals do not provide graphics capability.

b. Color Representation

Color is possible through use of a slide projector which is under computer control but as a separate display from the terminal itself.

c. Hardcopy

Hardcopy of CBI programs is available.

d. Keyboard

A standard alphanumeric keyboard is provided.

e. Touch Panel or Stylus

No capability for positional indicator devices are provided.

f. Fast Response

As with the commercial timesharing and UNIVAC systems, the COURSEWRITER III system would have to be in a priority processing position to achieve fast response times. Otherwise, there would most likely be periods of slower response than desirable.

g. Author Language

The COURSEWRITER III authoring system provides a simplified, easy to use programming capability for CBI.

h. Response Collection/Analysis

The COURSEWRITER III system is well designed for recording and managing student performance records. The records are available for either hardcopy or CRT display.

3.4.6 Control Data Corporation PLATO

The PLATO system, developed by the University of Illinois, is a large-scale network system exclusively designed and used for CBI. The system is well known in the military due to an ARPA-funded program for evaluation of PLATO in DoD. For these reasons it was studied for use at TRITRAFAC. Control Data Corporation (CDC) has committed corporate resources to making PLATO commercially available and it was the CDC PLATO version which was analyzed.

a. Dynamic Graphics

PLATO uses a plasma display which allows dynamic graphics.

b. Color Representation

A microfiche projection onto the rear of the plasma terminal provides the capability to display equipment panel colors.

c. Hardcopy

Hardcopy of displays on the plasma screens are available through a specially developed hardcopy device. Either listings or actual student displays may be copied.

d. Keyboard

PLATO has a full alphanumeric keyboard with special function keys for use in CBI programs by the student and author.

e. Touch Panel or Stylus

A touch panel is provided as a terminal option. The panel overlays the plasma screen.

f. Fast Response

The PLATO system at the University of Illinois is currently providing average response times of less than 0.2 seconds even with 400 users active. Since PLATO is designed and dedicated to CBI, it does not experience the slower times of large commercial timesharing systems.

g. Author Language

A CBI language which allows the unique features of PLATO terminals and system architecture, TUTOR, is provided.

h. Response Collection/Analysis

PLATO provides the capability to collect response data, perform analysis, and display summaries of data through programs which have been developed by users.

3.4.7 MITRE TICCIT

The MITRE corporation TICCIT system is currently being used in the Navy for aircraft personnel. The system is designed specially for CBI applications as a low cost but instructionally effective capability.

a. Dynamic Graphics

TICCIT does not have computer-generated dynamic graphics. The system does, however, have digitized static graphics and videotape. Since the videotape players are under computer control and do provide a motion capability, the decision was made to count TICCIT as fulfilling SWS training requirements on this must.

b. Color Representation

TICCIT provides both color graphics and color videotape.

c. Hardcopy

Hardcopy of CBI programs is available on TICCIT.

d. Keyboard

TICCIT has a full alphanumeric keyboard with special function keys related to instructional strategies using learner control of lessons.

e. Touch Panel or Stylus

At the time of the study, development was underway of a stylus capability for TICCIT.

f. Fast Response

Because of the TICCIT hardware and software design, fast response times of less than 0.2 seconds are achieved.

g. Author Language

TICCIT provides a complete authoring system based upon instructional strategies.

h. Response Collection/Analysis

The capability to record and analyze responses is provided.

3.4.8 Sylvania CTS

The Sylvania Computer Training System (CTS) was developed for the Army as a CBI system and is currently in use at Fort Gordon, Georgia. It is a minicomputer-based system.

a. Dynamic Graphics

CTS uses a modified Sylvania terminal with excellent graphics capability.

b. Color Representation

No color capability is provided currently with CTS.

c. Hardcopy

Hardcopy of program listings is available on CTS.

d. Keyboard

The Sylvania terminal has a full alphanumeric terminal with modifications to provide special CBI functions for authors and students.

e. Touch Panel or Stylus

No positional indicator capability is provided.

f. Fast Response

CTS achieves fast response times averaging less than 0.2 seconds by use of multiple processors for terminal control, file management, and system functions.

g. Author Language

A CBI author language, designed by Army personnel, is offered with CTS.

h. Response Collection/Analysis

Response data collection and analysis capability is provided.

3.4.9 CLASSIC

CLASSIC is a minicomputer-based system developed and marketed by Digital Equipment Corporation (DEC) which is very low cost relative to other CBI systems.

a. Dynamic Graphics

Dynamic graphic terminals and software are not standard in CLASSIC but can be purchased as options.

b. Color Representation

No color capability is available.

c. Hardcopy

Hardcopy listings are provided through the standard programming system.

d. Keyboard

A full alphanumeric keyboard is available.

e. Touch Panel or Stylus

No positional indicator is available.

f. Fast Response

DEC does not advertise a fast response and it is doubtful that this requirement could be met with a full set of graphics terminals on the system.

g. Author Language

CLASSIC uses the BASIC programming language with some CBI utility extensions.

h. Response Collection/Analysis

Response data collection and analysis is possible on CLASSIC.

3.4.10 General Electric CBTS

The General Electric Computer Based Training System (CBTS) is a recently developed, stand-alone CBI terminal, which incorporates the same plasma display used on PLATO. CBTS was the only stand-alone terminal system studied because it is the only system of this type available. It is actually not a computer per se but uses hard-wired components to perform similar functions.

a. Dynamic Graphics

CBTS has the same dynamic graphics capability as the PLATO system with the exception that displays are faster because of special hardware graphic features.

b. Color Representation

CBTS can represent color through projection of slides on the plasma screen and an optional second display for color graphics or videotape.

c. Hardcopy

Hardcopy is available through special author modules easily attached or removed from the student terminal.

d. Keyboard

A full alphanumeric keyboard with special function keys is provided. In addition, a portion of the plasma screen can be used to define special functions for authoring or student responding.

e. Touch Panel or Stylus

A touch panel is provided as an option which is overlaid on the plasma screen. In addition, panel mockups may be connected for higher fidelity simulations.

f. Fast Response

Because CBTS is a stand-alone terminal with hardware performing many functions normally done by software, response times are extremely fast. Average response times should be much better than the 0.2 seconds required.

g. Author Language

CBTS provides several levels of authoring languages which are easily learned and used.

h. Response Collection and Analysis

Response data collection and analysis is made possible through storage on a floppy disk with analysis routines either on a terminal or on a computing system.

3.4.11 Educational Computing Corporation EC II

Educational Computing Corporation (ECC) has developed a student station which allows various equipment panel mockups to be energized and operated under computer control. The system, EC II, does not provide CBI functions as defined for other systems considered. However, the panel learning stations have excited several branches of the military and therefore the capability was studied here.

In a different fashion, all the musts can, to some extent, be satisfied by EC II. Since the panel can actually consist of operating indicators, switches, and dials, all of the display and response musts are fulfilled. The stations do operate in near real time because each is controlled by a separate minicomputer. The only drawback, considering the list of musts, is in authoring. ECC usually performs the programming although a user could learn to do so. Estimates from ECC indicate a much higher relative cost for EC II programming than is incurred with more traditional frame-oriented CBI. The authoring is therefore probably more complex with EC II.

3.4.12 Other Candidates

Several other system possibilities were looked at briefly during the study but were determined not to be feasible for various reasons. One of these was the potential for CBI on the AN/UYK-20. It appears that the possibility of using this Navy-wide system for forms of CBI is being studied by other groups but it did not appear that the capability would be available in time for TRIDENT consideration or that the full range of musts could be satisfied. Another possibility was use of the Air Force Advanced Instructional System. However, it did not seem feasible at this time for the cognizant Air Force activities to commit the system for TRITRAFAC use, given that development is still underway for CBI simulation capabilities. Finally, no other computing system which was planned for TRITRAFAC had the CBI capabilities required.

3.5 CBI System Evaluations

As a result of comparing each candidate against the list of musts, decisions were made on a GO/NO GO basis. If a system met all requirements, it was analyzed further in terms of personnel and operational requirements for total life cycle costing.

Table 3-1 summarizes the results by system candidate and musts. Seven of the systems are clearly in the NO GO category according to the musts defined for SWS laboratory training. It should be noted that each of these seven have definite useful lives as CBI systems. The reason they do not fulfill TRIDENT needs is that they are not designed for equipment simulations of the sort required for SWS laboratories. The capabilities represented by systems 1, 2, 3, 4, 5, 8, and 9 are more appropriate for other types of learning such as theoretical, verbal, and concept.

Table 3-1

Evaluation of CBI Systems on a GO/NO GO Basis

System Candidates	Musts								Decision
	Dynamic Graphics	Color Representation	Hardcopy of CBI Curriculum	Keyboard	Touch Panel or Stylus	Fast Response	Author Language	Response Collection Analysis	
1. Hewlett-Packard	YES	NO	YES	YES	NO	?	YES	YES	NO GO
2. Navy CMI	NO	NO	YES	YES	NO	NO	YES	YES	NO GO
3. Commercial Time-sharing Systems	?	NO	YES	YES	NO	NO	?	?	NO GO
4. UNIVAC	YES	NO	YES	YES	NO	?	YES	YES	NO GO
5. IBM Coursewriter III	NO	YES	YES	YES	NO	?	YES	YES	NO GO
6. Control Data Corporation PLATO	YES	YES	YES	YES	YES	YES	YES	YES	GO
7. MITRE TICCIT	YES (See discussion for qualification)	YES	YES	YES	YES	YES	YES	YES	GO
8. Sylvania CTS	YES	NO	YES	YES	NO	YES	YES	YES	NO GO
9. Digital Equipment Corporation CLASSIC	YES	NO	YES	YES	NO	NO	YES	YES	NO GO
10. General Electric CBTS	YES	YES	YES	YES	YES	YES	YES	YES	GO
11. Educational Computing Corporation EC II	See section 4.11								NO GO

Three of the candidate systems do meet all musts. These are PLATO, TICCIT, and CBTS. PLATO and CBTS appear to have somewhat better capability for dynamic simulations using graphics, but TICCIT lessons can be designed to attain the same objectives with a combination of videotape and static graphics. All three systems have excellent authoring and response recording capabilities. In addition, each is designed for fast response times.

The EC II stations could be used for SWS laboratory training but a decision was made for NO GO on two factors. First, the CBTS terminals also have the capability for panel stimulation in addition to the traditional CBI. Therefore, both types of instruction are available on one system. Second, CBTS terminals and EC II stations are in the same cost range, about $25,000 to $30,000 each. The costs of panel simulations should be comparable. Portions of training on CBTS, with traditional CBI, will be less expensive. The result is that CBTS has more instructional power at less cost.

3.6 CBI Computing System Summary

Eleven CBI computing systems were compared to a list of eight absolute musts on a yes or no basis. If all eight requirements were met, a system received a GO decision which meant it would be studied further for manpower and procedural requirements. The total system machine and people, were then life-costed as described in section 4. Since the eight musts were established from an analysis of the specific environment of TRIDENT SWS laboratory training, only those CBI systems appropriate were final candidates. The three CBI systems receiving GO decisions were PLATO, TICCIT, and CBTS. In the remainder of this section, and in section 4, these three systems will be the center of the study.

3.7 CBI System Installation and Maintenance

The installation and maintenance of the hardware/software component of a CBI system is broken down into three elements:

a. Physical installation of the hardware/equipment and system testing of the hardware/software.

b. Hardware/equipment maintenance and operational support throughout the system life-cycle.

c. Computer software maintenance and updates over the system life-cycle.

It has been assumed that the facility and personnel requirements to perform the physical installation of the CBI system will be the joint responsibility of the Weapons Program Coordinator (WPC), the Facilities

Program Coordination (FPC), and the CBI system contractor. Since space has been designated within TRITRAFAC for the CBI system, normal power and environmental conditions should be available prior to installation. A crew of on-site personnel should be provided as required to assist in the unpacking, moving, hook-up, etc. of the hardware/equipment. Personnel will be furnished by the CBI system contractor for the initial installation and system testing. The specific types of personnel and numbers required are a function of the hardware/software configuration.

The personnel requirements for hardware maintenance and software maintenance are determined by the system characteristics and the support features offered by the CBI system contractor. Paragraphs 3.7.1, 3.7.2, and 3.7.3 outline the specific personnel required to install and maintain each CBI system alternative.

3.7.1 TICCIT Personnel Requirements

MITRE Corporation is responsible for the systems integration effort required to install the TICCIT system. This includes coordinating the procurement of the system components from various vendors, providing documentation on hardware operating and maintenance procedures from the vendors, arranging factory training on major system components, conducting a site survey to determine facility requirements, preparing an installation design layout, determining the initial spares requirements, etc.

System integration and testing is conducted at the MITRE facility before components are shipped to the site for installation. Due to the complexity of installing the system, several computer technicians and/or installation specialists will be required from the on-site personnel crew to support the physical installation effort. MITRE provides on-site personnel for 6 weeks after system delivery to ensure that the system is operational. On-call service is provided by MITRE for 6 months after delivery for troubleshooting and operational support.

There are two options available for TICCIT computing hardware support: (a) a blanket maintenance agreement with Data General, or (b) on-call services from Data General. In the first case, a set fee per year covers scheduled preventative maintenance, repairs, replacements, and replenishment spares for the major system components. To supplement this support, an estimate of one-and-a-half full-time military technicians is required to maintain the non Data General system components--for example, MITRE supplied equipment and terminals. This would include preventative maintenance, trouble analysis and isolation, minor replacements and repairs, and system operator functions. The second option will require at least three full-time military technicians to support all the system components and perform system operator functions. In addition, on-call service from Data General, replacement parts, and replenishment spares would have to be procured. Due to the fact that TICCIT system integration has not been completed, the first maintenance option is recommended for the TRITRAFAC installation to minimize potential problems.

MITRE has the charter for software development for the TICCIT system, but it does not have responsibility to support the existing software. Therefore, it is recommended that an on-site system programmer be available full-time for software maintenance, debug, and operational support.

In summary, the minicomputer configuration of the TICCIT system presents specific installation and maintenance requirements. On-site personnel must be available to assist MITRE representatives in the system installation and one-and-a-half full-time military technicians, as well as a full-time systems programmer, are required to support system operation.

3.7.2 PLATO Personnel Requirements

The marketing policy established by Control Data Corporation (CDC) for the PLATO system provides a full range of installation and maintenance services. CDC personnel assist in the equipment installation design and layout and ensure that the facility meets operational requirements. Physical installation and testing of the terminals on-site is performed by CDC customer engineers with little assistance. A monthly terminal maintenance charge includes scheduled preventative maintenance, on-call field service (with a maximum 2-hour response time), and spares and replacement parts as required. A monthly multiplexor service charge covers maintenance on the necessary communications equipment. PLATO software support includes special communications equipment interfaces, authoring language facility, and lesson execution facility at no charge to the user, as well as access to any new software modifications and improvements.

The installation and maintenance of a cluster of remote PLATO terminals tied into a central CDC network imposes no additional personnel requirements for TRITRAFAC. However, it is recommended that a military technician be available one quarter of the time for problem isolation and general upkeep on the terminals.

3.7.3 CBTS Personnel Requirements

General Electric Ordnance Systems (GEOS) has development and marketing responsibility for CBTS stand-alone terminals. GEOS engineers will provide an equipment installation design and layout and ensure that the facility meets operational requirements. Physical installation, hook-up, and functional/operational testing will be accomplished by GEOS engineers with minimal support from on-site personnel.

Support for CBTS includes a hardware maintenance panel and a software maintenance diskette. A full complement of spare modules and components will be available on-site. Failed modules will be replaced and returned to GEOS for repair or for replenishment spares. GEOS engineers will be available for diagnostic testing and repair as required and any software updates will be provided to the user by GEOS.

The installation and maintenance of a small number of CBTS stand-alone terminals does not require additional TRITRAFAC personnel. However, it is recommended that a military technician be available one-half of the time for preventative maintenance on the terminals and peripherals, trouble analysis and fault isolation, module replacement, floppy disk reproduction, and general upkeep.

3.8 CBI Courseware Development

The approach to determine the personnel configuration required to develop courseware for each CBI system candidate consisted of the following five steps:

a. The development functions and general types of personnel were identified and possible personnel mixes for each system were extrapolated. Paragraph 3.8.1 details the personnel mixes.

b. A survey of military users involved in CBI courseware development was conducted. The data gathered for TICCIT/PLATO users was analyzed in light of the TRIDENT CBI training requirements to determine an estimate of the number of man-hours required to develop 1 CBI hour. This process is described in detail in paragraph 3.8.2.

c. Once an estimate of the number of man-hours to develop 1 CBI hour was derived, the media support requirements for each candidate had to be analyzed. Paragraph 3.8.3 summarizes the impact of media support on courseware development.

d. A proposed CBI courseware development schedule was created in conjunction with the TRIDENT Curriculum Development Schedule to provide a timeframe for implementation. The assumptions and constraints used to derive this schedule are discussed in paragraph 3.8.4.

e. As a final step, the estimate of the number of man-hours to develop 1 CBI hour was broken down by the appropriate personnel mix for each system candidate and phased over the CBI courseware development schedule. This process and the resulting personnel configuration for each alternative is described in paragraph 3.8.5.

3.8.1 CBI Personnel Mixes

Certain functions are essential to develop CBI courseware. These functions include:

a. A task analysis to establish the hierarchy of learning objectives to be met.

b. Determination of an instructional strategy treatment.

c. Accurate instructional content to support the learning objectives.

d. Translation of the instructional strategy and instructional content into the computer software system.

e. Editing of the lesson material for technical and programming inaccuracies.

f. Production of instructional media materials to support lesson material.

g. Formative and summative evaluation of the courseware for instructional effectiveness.

The personnel required to accomplish these functions are categorized in the following manner:

a. Instructional Technologist (IT) performs the task analysis, instructional design, and evaluation of the courseware.

b. Subject Matter Expert (SME) assists in the instructional design and evaluation of the courseware, provides the instructional content, and edits the lesson material for technical accuracy.

c. Author has the primary responsibility for generating the courseware.

d. Programmer codes and enters the lesson material into the computer software and debugs errors.

e. Media Specialist supervises and/or produces the required instructional media materials.

These personnel categories are not mutually exclusive, in that one individual can perform several of the functions and/or several individuals can perform one function. To a large extent, the available manpower and personnel resources determine the mix of personnel within these categories. For example:

a. The author, SME, and programmer can be one, two or three individuals.

b. Several authors can share the responsibility for developing one lesson.

c. The programmer duties can be divided among several skill levels, such as complex programming, off-line preparation, on-line coding, clerical data entry, etc.

Utilizing these personnel categories as a baseline, typical personnel mixes for the CBI system candidates are described in the following paragraphs.

3.8.1.1 Authoring System

Courseware development on the TICCIT system is accomplished by means of a prestructured authoring system rather than a general-purpose authoring language. The TICCIT courseware structure provides for the separation of instructional strategy from instructional content and, as such, a conventional authoring language is not of primary importance. The hierarchial structure focuses on a forms-oriented system that allows for an efficient division of labor to prepare the instructional content and provides for a convenient flexible method to enter the instructional content.

The authoring system concept features an authoring team approach that consists of three major elements:

a. Off-line design and preparation of the lesson material is handled by a senior author/SME, several assistant authors/SMEs, and an IT.

b. A quality control committee consisting of an SME, part-time Instructional Psychologist, and media specialist reviews and edits the lesson material.

c. A packaging group converts the author drafts into computer format and enters the lesson material on-line, as well as producing and editing the digitized graphics to support the lesson material.

Drawing from the authoring team approach, the typical personnel mix for TICCIT courseware development centers on a core of authors/SMEs, one or two ITs, and a programmer/packaging/data entry group. Media support is discussed in paragraph 3.8.3.

3.8.1.2 Authoring Language

Both the PLATO system and the CBTS stand-alone terminal feature high-level authoring languages for courseware development. The language utilized by each system was designed for authors with no prior knowledge of computers so that, with a minimal amount of training and experience on-line at the terminal, the author can produce lesson material. Both TUTOR and the CBTS language emphasize powerful, flexible commands that are relatively simple for the author to use.

No separation of instructional strategy from instructional content is inherent within the authoring language concept, so the author becomes the central figure in courseware development. For efficiency's sake, the author is usually an SME trained in the authoring language rather than a programmer that has become familiar with the subject matter.

Within this context, two approaches to courseware development have been adopted; one focuses on the "independent author," while the other one features a "quasi-team." In the traditional unstructured environment, the individual author utilizes his ingenuity, subject matter expertise, and programming experience to design and develop lesson material independently.

In the quasi-team approach, the author/SME is the focal point within a group of specialized personnel that contribute to the development effort. The following types of personnel are examples of team members that might be available:

a. IT to identify the learning objectives and assist in the instructional design, as well as review and evaluate the lesson material.

b. Media specialist to plan for the use of audio and visual material in the lesson.

c. Coders to assist in the more mechanized programming tasks.

d. Additional SME to supplement the author/SME's knowledge about the instructional content and to edit the lesson material for technical accuracy.

As a compromise to the two approaches and as means of ensuring instructional quality, the best personnel mix for both PLATO and CBTS courseware development seems to be typified by a core of author/SME/programmers and one IT. Media support is discussed in paragraph 3.8.3.

3.8.2 CBI Courseware Development Man-Hours

In order to derive an estimate of the number of man-hours required to develop 1 CBI hour, a survey of military activities currently involved in courseware development was conducted. Nonmilitary educational institutions, such as universities, involved in CBI courseware development were not included in the survey. Literature searches revealed estimates of 100 to 400 man-hours per hour of instruction in the academic setting. However, it was felt that the lesson characteristics were not comparable because technical training provides for a specific set of skills and a certain level of proficiency, while much of education provides for generalized mastery and concept formulation.

3.8.2.1 Survey of Current Military Users

There were several problems inherent in compiling and analyzing the data available on courseware development. A major difficulty was to define the term "CBI hour." For the purpose of this study, it is defined as three or four learning objectives that an average student would complete in 1 hour at a CBI terminal.

Proceeding from this baseline, a definition of the activities included in the estimated number of man-hours was required. Media support time for 35mm slides, microfiche, and videotape production is not included in any of the development estimates. Also, all development estimates assume that the learning objectives were previously established, either by existing lesson material or by a separate task analysis, so no man-hours for this activity are included.

The man-hour estimates obtained include design, implementation, debug, validation, and revision of CBI lesson material with the exception of the estimates obtained from a CBI project at Maxwell Air Force Base. Maxwell began a study in April 1975 to compare PLATO, TICCIT and revised conventional instruction. A task analysis of the two pilot courses established the learning objectives to be used for the three instructional methods, and on-line courseware development for TICCIT and PLATO started in June. The Maxwell estimates include design, implementation, and debug. Validation and revision will not begin until the pilot courses are completed next summer.

The number of CBI hours developed by each activity was also acquired and used as an experience level indicator. Estimates of the first few CBI hours developed usually include such factors as training time for authors, organization of personnel assignments, and unfamiliarity with the subject matter. As the number of CBI hours developed increases, the number of man-hours for development decreases due to greater authoring efficiency and better personnel organization. The number of man-hours per CBI hour shown in Table 3-2 are estimates of the average number of man-hours for development and, as such, take into consideration the experience level for each activity.

The estimates in Table 3-2 for the percent of terminal contact time required to develop 1 CBI hour were best guesses. Many factors, such as individual preferences for programming, complexity of lesson material, availability of CBI terminals, and programming experience also influence this figure. Fifty percent terminal contact time per CBI hour appears to be the average estimate. This figure is used in the calculations in paragraph 3.9.3.

Table 3-2

Survey of Current Military Users of CBI Systems

Activity	Development Agency	Lesson Material	Lesson Characteristics	Personnel Mix For Development	# CBI Hours Dev.	# Man-hours/ CBI Hr.	% Term. Contact/ CBI Hr.
PLATO							
Chanute Air Force Base, IL	AF Human Resources Lab, Air Training Command	Automative Course	Cognitive Textual Tutorial Microfiche Computer graphics Animation Interface via keyboard No touch panel	AF Instructional Design Team (ITs) 7 Authors/programmers/ SME (AF instructors - no computer or TUTOR experience) 1 Programmer/coder	31	145	50
Aberdeen Proving Grounds	U.S. Army Ordnance Center and School	Machinist Course	Hard Skill Problem Solving Tutorial No microfiche Computer graphics Animation Interface via keyboard Limited touch panel use	1 IT 4 to 7 Authors/programmers/ SME (Army Instructors - no computer or TUTOR experience)	30	284	50
Maxwell Air Force Base, AL	Air Univ-ersity/ Education	Food Service Specialist/ Material Facilities Specialist	Low level memory Rule Utilization Tutorial Microfiche Computer graphics Animation Interface via keyboard Limited touch panel use	2 ITs 2 Programmers (computer experience) 4 Authors/SME	2	400	60

Table 3-2 (Continued)

Activity	Development Agency	Lesson Material	Lesson Characteristics	Personnel Mix For Development	# CBI Hours Dev.	# Man-hours/ CBI Hr.	% Term. Contact/ CBI Hr.
PLATO (Continued)							
Guided Missile School Dam Neck VA	General Electric Ordnance Systems (GEOS)	Test Panel Keyboard Subsystem	Equipment Simulation Skilled and knowledge objectives Description, operations, and functions Microfiche Dynamic graphics Touch panel	1 IT 1 Author/programmer/SME (computer experience)	4 1/2-6	156	60
Naval Training Center, San Diego	Navy Personnel Research and Development Center (NPRDC)	Co-pilot	Equipment Simulation Skills and knowledge objectives Description, operations, and functions No microfiche Dynamic graphics Extensive touch panel use Interactive learner control	1 IT .25 SME 2 Authors/programmers (TUTOR experience)	2-3	584	60
CBTS							
GEOS	GEOS	Test Panel	Equipment Simulation Skill and knowledge objectives Description, operations, and functions Sonic pen Dynamic graphics	1 IT 1 Author/programmer/SME (no computer experience)	In prog.	To be determined	To be determined

Table 3-2 (Continued)

Activity	Development Agency	Lesson Material	Lesson Characteristics	Personnel Mix For Development	# CBI hours Dev.	# Man-hours/ CBI Hr.	% Term. Contact/ CBI Hr.
<u>TICCIT</u>							
Maxwell Air Force Base, AL	Air University/ Education	Food Service Specialist/ Material Facilities Specialist	Low level menory Rule utilization Tutorial Digitized graphics Videotape	2 ITs 2 Programmers/packagers/ data entry 5 Authors/SME	3	400	50
Naval Air Station, North Island	NPRDC/ Courseware, Inc.	S-3A Aircraft Operations	Low level memory Rule utilization Concept formulation Digitized graphics	1 Instructional Psychologist 2 ITs 3 Programmers/packagers/ data entry 10 Author/SME	100+	200	50
Guided Missile School, Dam Neck, VA	GEOS, MITRE, Courseware, Inc.	Test Panel	Skill and knowledge objective Description, operations, & functions Digitized graphics Videotape	1 Instructional Psychologist 1 IT 2 Programmers/packagers, data entry	3-4	Impossible to deter-	Impossible to deter-

3.8.2.2 Analysis of Survey Data

The purpose of the survey on courseware development was to derive an estimate of man-hours required to develop 1 TRIDENT CBI hour for each CBI system candidate. Several factors had to be considered:

a. The characteristics of the lesson, especially the complexity of the materials, had to be compared to each other and to the TRIDENT training requirements identified in section 2 of this report for similarities and discrepancies. On this basis, the co-pilot course developed by NPRDC on PLATO is not included in the TRIDENT estimate. The equipment simulation is more complex, and the instructional strategy employed to develop the lesson material is more sophisticated than the other users.

b. The number of man-hours per CBI hour shown in Table 3-2 for each activity are averages that take into account the number of CBI hours developed by that activity. In reviewing the estimates for PLATO and TICCIT, a range of 145 to 284 man-hours is isolated if the Maxwell estimates are not included. Since the Maxwell study is still in the early stages and a small percentage of the learning objectives have been completed, these estimates for PLATO and TICCIT are not representative and they are not included for the TRIDENT estimate.

c. An analysis of the differences in development hours between the system candidates was necessary. Although the Maxwell estimates are not included for the reasons stated in (b) above, an interesting observation was made. There appears to be no difference between TICCIT and PLATO in the number of man-hours required to develop 1 CBI hour. Both systems were installed at approximately the same time, both systems are utilizing a quasi-team approach, and both systems are developing the same learning objectives. Although the systems have different configurations, capabilities, and features, the development efforts are the same size.

The TICCIT estimate of 200 man-hours from NAS North Island compares favorably with the 195 man-hour estimate that resulted from computing the average of the PLATO users (specifically Aberdeen, Chanute, and GMS).

Since CBTS is a new system and the first courseware is only now being implemented, no estimate of the number of man-hours to develop 1 CBI hour are available. It is assumed that the estimate for CBTS will be no more than PLATO since both systems utilize a high-level authoring language and require a similar personnel mix for courseware development.

3.8.2.3 Estimate for TRIDENT CBI Development

The analysis of the survey data resulted in a figure of approximately 200 man-hours to develop 1 CBI hour across the three system candidates. This 200-hour estimate includes design implementation, debug, validation, and revision of CBI lesson material, but it does not include establishing the learning objectives and formalizing the instructional strategy to be used to support the learning objectives.

Learning objectives should be established for the TRIDENT CBI courseware in the form of third-stage Instructor Guides. However, formalizing of the instructional strategy and a further refinement of the objectives will be required. Based on this requirement, additional analysis will be necessary regardless of the CBI system selected. An estimate of 50 man-hours per CBI hour was considered reasonable. Therefore, a little over 1 man-week is allowed for three or four training objectives. This figure was assumed to be constant across the three system candidates, although the instructional strategy to be used and the personnel mix required to accomplish the effort will vary.

To summarize, the estimate for TRIDENT CBI courseware development consists of two components: (a) 50 man-hours per CBI hour for analysis, and (b) 200 man-hours per CBI hour for courseware development. These components are costed out as separate elements in section 4, but the total of 250 man-hours per CBI hour is used for computation of personnel numbers in the remainder of this section.

3.8.3 Media Support

The media support requirements of each CBI system were investigated to determine any impact on the estimate for courseware development. As identified in the training analysis, it is essential to simulate the tactical training hardware. Each CBI system candidate has unique media support requirements to achieve this simulation capability.

3.8.3.1 TICCIT Requirements

The TICCIT system utilizes digitized graphics and videotape as additional media beyond computer-generated text. Both media were determined to be necessary for TICCIT to meet TRIDENT training requirements.

The process to create digitized graphics for integration into the lesson material involves three steps:

a. An illustrator produces the graphics off-line.

b. An operator enters the graphics into the computer system by means of the graphic digitizer.

c. The programmer/packager/data entry personnel edit the graphics stored on disk.

The estimate of 250 man-hours per CBI hour was considered sufficient to include the production of digitized graphics. The development estimate provided by the TICCIT user at NAS North Island included the man-hours required to digitize and edit graphics, but it did not include the off-line illustrator time. It has been assumed that no additional personnel will be required since an illustrator will be available at TRITRAFAC to produce the CBI graphics off-line as required. However, an additional 10 man-hours per CBI hour was included in the development estimate for off-line graphics production. The cost associated with the additional hours is reflected in paragraph 4.3.2 of section 4.

An average of 5 minutes of videotape per CBI hour was used as an estimate for the TRIDENT training requirements. Rather than determining the number of man-hours required to support videotape production and adding that figure to the 250 man-hours per CBI hour estimate, a dollar figure was added to the courseware development costs for the TICCIT system. Paragraph 4.3.2 in section 4 provides detailed information.

3.8.3.2 PLATO Requirements

The media support features for PLATO, beyond computer-generated text, include computer-generated graphics and microfiche slides; both of which are needed to fulfill requirements for the TRIDENT application. The procedure for developing computer-generated graphics is considered to be an integral part of the author/programmer's task and, as such, is already included in the 250 man-hour estimate.

The process for developing microfiche slides involves producing 35mm color slides of the desired materials, sequencing the slides, and sending them to CDC to be converted to microfiche. Since a photographer will be available at TRITRAFAC, it has been assumed that no additional personnel will be required. However, an estimated 5 man-hours per CBI hour was added to the courseware development man-hours for producing the 35mm color slides. Paragraph 4.4.2 of section 4 reflects the costs associated with the additional man-hours.

An estimate of one microfiche slide, containing up to 256 images for each CBI hour, was considered more than adequate to meet the training requirements. Since the microfiche processing will be done off-site by the CBI contractor, it was determined that adding a dollar figure for the master slide and the required number of copies would be a more reasonable approach than adding man-hours to the development estimate. Paragraph 4.4.2 of section 4 details the additional costs per CBI hour for microfiche processing.

3.8.3.3 CBTS Requirements

The CBTS stand-alone terminal utilizes 35mm color slides and computer-generated dynamic graphics for media support. As is the case with PLATO, dynamic graphics are considered to be an integral part of the author/programmer's task and no additional man-hours are required. However, an additional 5 man-hours per CBI hour for the production of 35mm color slides is included in the courseware development costs shown in paragraph 4.5.2 of section 4.

3.8.4 CBI Courseware Development Schedule

In order to determine the personnel configuration for CBI courseware development, a timeframe for implementation had to be created in conjunction with the Instructor Guide (IG) development period. IGs are developed in five stages. The activities within each stage include: (a) scheduling and planning, (b) development of a sample portion of curricula, (c) development of the balance of the curricula, (d) conducting the pilot course, and (e) finalizing and distributing the curricula.

All of the instructional units selected in section 2 to be put on CBI were within the replacement training courses for fire technicians and missile technicians. The latest version of TAPS (Training Acquisition Program for Software, September 22, 1975) available at the time of the study specified the curriculum development schedules for TRIDENT I FTB and MT replacement training. TAPS provides the scheduled start and complete dates for the five stages, including a sustaining period during third stage development and a period for instructor personalization prior to the start of the pilot course in the fourth stage. These IG development schedules were analyzed to determine CBI development schedules.

It is recommended that CBI courseware development be phased over a 3-year period, beginning in FY77 and continuing through FY79. This start-up date coincides with third stage development of the IGs and this completion date parallels fifth stage promulgation of the IGs as indicated in TAPS.

It is suggested that a schedule calling for a specific number of CBI hours to be completed each year be instituted rather than phasing the development activities for all of the CBI hours over the total period. This approach offers several advantages. For one thing, when the development effort begins, the specifications and procedures for CBI courseware within the FBM Training System will not be finalized. Developing a small number of hours in the first year provides a means to verify the specifications and procedures and eliminate any problems in the documentation. It also allows for a staged build-up of personnel and provides an opportunity to work out organizational problems.

It is recommended that 10 hours be completed in FY77 and that the remainder of the hours be divided over FY78 and FY79 for completion. Figure 3-1 depicts this proposed CBI implementation time frame in relation to the IG development schedule.

3.8.5 Personnel Configuration Methodology

The method to project the personnel configuration for each CBI system candidate involved several steps. First, the typical personnel mix for each alternative was identified as described in paragraph 3.8.1. In order to relate the personnel mix to the development estimate, a percentage of effort by personnel type per man-hour was required. It was assumed that the same personnel mix and percentage of effort applied to the 50 man-hours per CBI hour for analysis and the 200 man-hours per CBI hour for development. Utilizing the proposed CBI implementation schedule shown in Figure 3-1, the number of man-hours and man-years per fiscal year was computed. Finally, a breakdown in man-hours and man-years by personnel type was calculated to arrive at the exact personnel requirements. Figure 3-2 lists the assumptions and shows the formulas used to calculate the personnel configuration for each candidate.

3.8.5.1 TICCIT Personnel Requirements

Courseware, Inc. supplied the recommended personnel mix and number of man-hours expended by personnel types based on previous military development efforts. From this data, a percentage of effort per man-hour by personnel type was derived for the TRIDENT personnel mix identified in paragraph 3.8.1. Table 3-3 presents the personnel types and percentage of effort, as well as specifying the personnel requirements for TICCIT by fiscal year.

3.8.5.2 PLATO Personnel Requirements

Based on information gathered while surveying the current military users, a percentage of effort by personnel type per man-hour was derived for the personnel mix identified for PLATO. Table 3-3 shows the personnel mix and percentage of effort, as well as specifying the personnel requirements for PLATO by fiscal year.

3.8.5.3 CBTS Personnel Requirements

Since courseware development is in progress and no data is available at this time, it has been assumed that the personnel mix and the percentage of effort for CBTS would be the same as for PLATO.

IG DEVELOPMENT SCHEDULE

Stage 1	Stage 2	Stage 3		Stage 4	Stage 5

CY 75	CY 76	CY 77	CY 78	CY 79

PROPOSED CBI SCHEDULE

10 CBI Hours — Stages 3,4,5 — FY 77

26.25 CBI Hours — Stages 3,4,5 — FY 78

28 CBI Hours — Stages 3,4,5 — FY 79

Figure 3-1. CBI implementation schedule

Assumptions:

1. 250 man-hours to develop one CBI hour

2. 64.25 CBI hours phased over three years:

   10.00 hours in FY 77
   26.25 hours in FY 78
   28.00 hours in FY 79

3. 2080 man-hours per man-year

4. Personnel mix and percentage of effort per personnel type unique to CBI candidate

Calculations:

1. Same formula repeated for each fiscal year:

   No. of man-years/1 CBI hour x No. of CBI hours/FY =

   No. of man-hours/FY x 1 man-year/No. of man-hours =

   No. of man-years/FY

2. Same formula repeated for each personnel type:

   % x No. of man-hours/1 CBI hour x No. of CBI hours/FY =

   No. of man-hours/FY x 1 man-year/No. of man-hours =

   No. of man-years/FY

Figure 3-2. Methodology for personnel configuration

Table 3-3

CBI Courseware Development Personnel Requirements

CBI SYSTEM ALTERNATIVE	FY 77	FY 78	FY 79
	2,500.00 man-hours	6,562.50 man-hours	7,000.00 man-hours
	1.20 man-years	3.16 man-years	3.37 man-years
TICCIT Personnel Mix			
.05 IT	125.00 man-hours	328.12 man-hours	350.00 man-hours
	.06 man-years	.16 man-years	.17 man-years
.30 Programmer/packager/data entry	750.00 man-hours	1,968.75 man-hours	2,100.00 man-hours
	.36 man-years	.95 man-years	1.01 man-years
.65 Author/SME	1,625.00 man-hours	4,265.63 man-hours	4,550.00 man-hours
	.78 man-years	2.05 man-years	2.19 man-years
PLATO/CBTS Personnel Mix			
.20 IT	500.00 man-hours	1,312.50 man-hours	1,400.00 man-hours
	.24 man-years	.63 man-years	.67 man-years
.80 Author/programmer/SME	2,000.00 man-hours	5,250.00 man-hours	5,600.00 man-hours
	.96 man-years	2.53 man-years	2.70 man-years

3.8.5.4 Summary

The effort required to develop the 64.25 CBI hours, regardless of the CBI system candidate, is estimated to be 7.73 man-years spread over a 3-year period beginning in FY77. The personnel mix required to develop the courseware and the media materials required to support the courseware are a function of the CBI system alternative.

3.9 CBI Courseware Maintenance

CBI courseware maintenance consists of two elements: (a) maintaining the accuracy and currency of the instructional content, and (b) correcting any instructional deficiencies identified through continuous student usage. In order to determine the personnel required to support courseware during the projected life-cycle of TRIDENT, both elements had to be analyzed.

Paragraph 3.9.1 discusses several approaches attempted to determine the maintenance effort. Paragraph 3.9.2 describes the final methodology utilized to determine the maintenance effort. Paragraph 3.9.3 then presents the maintenance personnel requirements for each system candidate.

3.9.1 Analysis of Maintenance Effort

Several steps were taken in an attempt to determine the level of effort required to keep the CBI instructional content current. A thorough review of the SSBN Training Materials Support Program was conducted. Paragraph 3.11.4 provides a brief overview of this feedback system. The procedures established to keep the curriculum current are well-defined but there is no way to monitor the associated level of effort required to keep the IGs up-to-date with changing hardware/software, operating techniques, and training requirements. Since many of the specifications for the TRIDENT tactical equipment and/or stimulators/simulators used for training are in a state of flux, it is difficult to anticipate the magnitude of the changes. For example, changes in operational sequence, placement of buttons on a console, and maintenance theory will each impact the curriculum.

However, an analysis of training activity Trouble and Failure Reports (TFRs) submitted in FY75 for POSEIDON curriculum was undertaken as a means to estimate the magnitude of the changes for TRIDENT CBI. Information was incomplete for this purpose and no method was found to obtain further data. For example, the man-hours required to identify and complete changes were not available in the history of change documentation. Also, the changes were identified by NAVTECHTRA course number so any breakdown to determine the impact on the specific instructional units selected for CBI was not feasible.

Finding insufficient information on the anticipated level of effort required to keep the instructional content current, a different approach was taken. In the process of surveying the military activities currently involved in CBI courseware development, data on support requirements for completed CBI hours was sought. Again, little or no information was available. Such historic data is seldom kept by CBI user activities. The estimates given by TICCIT and PLATO users included the man-hours expended in the validation and revision cycle, but there was no breakdown on the man-hours required to keep the instructional content current and correct any instructional deficiencies identified once this cycle was completed.

3.9.2 Determination of Maintenance Effort

With no baseline data available, the analysis team, based on CBI knowledge and experience, made several assumptions to determine the support effort. Reasonable estimates of the number of man-hours required to support TRIDENT CBI courseware were defined in the following manner and checked with additional CBI courseware personnel:

a. High Maintenance - One major change per CBI hour per year which takes 20 hours of terminal contact time will be required. In addition, high maintenance includes four minor changes per CBI hour per year which takes 5 hours of terminal contact time each. High maintenance is associated with the first few years after implementation.

b. Low Maintenance - Four minor changes per CBI hour per year which takes 5 hours of terminal contact time each will be required. Low maintenance follows high maintenance through the life of the CBI curriculum.

These two levels of maintenance were phased over the courseware life-cycle with the proposed CBI implementation schedule identified in paragraph 3.8.4. It is anticipated that the number of changes required to keep the instructional content current and to correct any instructional deficiencies will be greater in the period immediately following development and prior to steady-state training. This period corresponds to the high maintenance effort. Figure 3-3 illustrates the anticipated life-cycle maintenance effort for each fiscal year.

3.9.3 Maintenance Personnel Requirements

Figure 3-3 was used as a baseline to determine the personnel required to maintain CBI courseware. The following assumptions were made in projecting the personnel configuration for each CBI system alternative:

a. The same personnel mix and percentage of effort shown for courseware development in Table 3-3 apply to courseware maintenance.

```
LIFE-CYCLE           1_____1_____1_____1_____1_____1_____1_____1_____1_____1_____1
                       FY 76 FY 77 FY 78 FY 79 FY 80 FY 81 FY 82 FY 83 FY 84 FY 85

COURSEWARE DEVELOPED

   10.00 CBI hours         1__D__1_High_1
                             FY 77 FY 78

   36.25 CBI hours               1__D__1_High_1
                                   FY 78 FY 79

   64.25 CBI hours                     1__D__1_High_1_High_1_Low__1_Low__1_Low__1_Low__1
                                         FY 79 FY 80 FY 81 FY 82 FY 83 FY 84 FY 85

LEGEND

   D = development effort      High = high maintenance effort      Low = low maintenance effort
```

Figure 3-3. CBI Courseware life-cycle maintenance

b. The percentage of terminal contact time for each system was based on the survey of current military users--50% for TICCIT, PLATO, and CBTS.

c. The same formula was used for each CBI system candidate and for each fiscal year. For a low maintenance period, the formula below was utilized. High maintenance is twice this low maintenance formula.

No. of man-hours of terminal contact time/1 CBI hour ÷ % terminal contact time = No. of man-hours/CBI hour x No. of CBI hours/FY = No. of man-hours/FY.

d. The same formula indicated in Figure 3-2 was used for each personnel type.

e. The media support requirements were considered negligible.

Table 3-4 summarizes the maintenance personnel requirements for each candidate by fiscal year in the same format utilized in Table 3-3 to summarize the development personnel requirements.

3.9.4 Summary

The maintenance effort projected over the life-cycle of CBI courseware requires a stepped personnel build-up that peaks in 2.47 man-years of effort per year for FY80 and FY81. This coincides with the completion of all 64.25 CBI hours as shown in the proposed implementation schedule. The support effort is anticipated to reduce significantly in FY82 through FY85 since changes in equipment, operating procedures, and maintenance techniques should be at a minimum and any instructional deficiencies should be corrected by this time. An estimate of 1.24 man-years of effort per year is projected for these 4 years.

3.10 FBM Training System Documentation

The necessary information and planning techniques required to acquire an FBM Training System are provided in NAVORD OD 45260 prepared by the Strategic System Project Office. Within the general framework of the SSPO policy statements contained in this document, a set of procedural documents that define the tasks and identify the roles and responsibilities necessary to establish and maintain an FBM Training System have been promulgated for use by contractors. Figure 3-4 lists these documents and shows their interrelationships.

Table 3-4

CBI Courseware Maintenance Personnel Requirements

	FY 78	FY 79	FY 80 and FY 81	FY 82 through FY 83
CBI SYSTEM ALTERNATIVE	800.00 man-hours	2,900.00 man-hours	5,140.00 man-hours	2,570.00 man-hours
	.38 man-years	1.39 man-years	2.47 man-years	1.24 man-years
.05 IT	40.00 man-hours	145.00 man-hours	257.00 man-hours	128.50 man-hours
	.02 man-years	.07 man-years	.12 man-years	.06 man-years
.30 Programmer/packager/ data entry	240.00 man-hours	870.00 man-hours	1,542.00 man-hours	771.00 man-hours
	.11 man-years	.42 man-years	.74 man-years	.37 man-years
.65 Author/SME	520.00 man-hours	1,885.00 man-hours	3,341.00 man-hours	1,670.50 man-hours
	.25 man-years	.90 man-years	1.61 man-years	.81 man-years
.20 IT	160.00 man-hours	580.00 man-hours	1,028.00 man-hours	514.00 man-hours
	.07 man-years	.27 man-years	.49 man-years	.25 man-years
.80 Author/programmer/ SME	640.00 man-hours	2,320.00 man-hours	4,112.00 man-hours	2,056.00 man-hours
	.31 man-years	1.12 man-years	1.98 man-years	.99 man-years

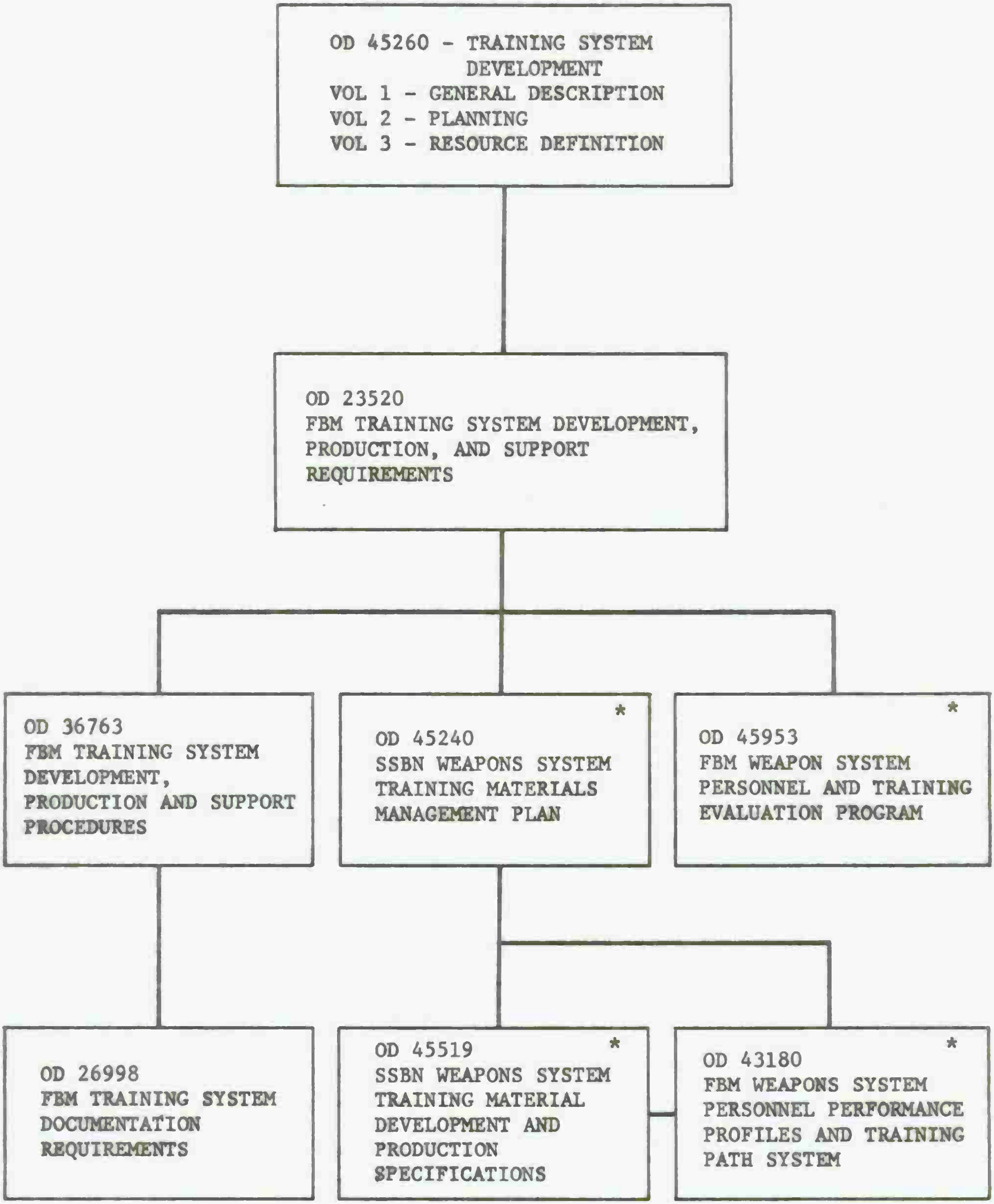

Figure 3-4. FBM Training System Documentation prepared by Strategic Systems Projects Office (NAVORD)

Modifications to the documents specifying the requirements and procedures for development, production, and support of an FBM Training System are not required for the purpose of CBI implementation. Only the documents that address development and support of training materials for an FBM Training System are relevant. These documents are identified by asterisks in Figure 3-4 and discussed in detail in paragraph 3.11.

3.11 SSBN Weapon System Training Materials Program

NAVORD OD 45240 defines the required procedures, responsibilities, and task sequences for development, validation, verification, production, and support of SSBN Weapon System Materials. The following paragraphs describe the Training Program participants, organization, and elements.

3.11.1 Program Participants

Certain activities and agencies perform vital roles in the development and support of training materials. A definition of the generic terms used to refer to the participants is provided below:

- TA The Training Agency is an office, bureau, command, or headquarters exercising command of and providing support to some major increment of the Navy's formalized training effort.

- TSA The Training Support Agency is an office, bureau, command, or headquarters responsible for supporting the training agencies by providing material and other forms of support within the cognizance of the office, bureau, or command involved.

- TF The Training Facility is a U.S. Navy installation where formal training is conducted.

- PPC The Personnel Program Coordinator is an organization responsible for planning, designing, and providing a fully operational personnel subsystem under the direction of the TSA. The PPC provides coordination and review of training material development and support as directed by the TSA.

- MPA The Materials Preparing Activity is an organization, either a contractor or a Navy activity, that develops, revises, and/or produces training materials as directed by the TSA or TA.

- MSA The Materials Support Activity is an organization, either a contractor or a Navy activity, responsible for training materials surveillance as directed by the TSA or TA.

MCA The Materials Change Activity is an organization, either a contractor or a Navy activity, that develops changes to training materials as directed by the TSA or TA.

3.11.2 Program Organization

The TSA is responsible for implementation of the training program and ensures that interface among the program participants is established and maintained. The TA is the final approval authority of materials developed for use in the formal training environment, while the TSA is the final approval authority for materials not used directly in the formal school environment. The assignment of the MPA, MSA, and MCA functions to either contractors or Navy activities is coordinated by the TA and TSA. The TA directs these functions if they are assigned to Navy activities, while the TSA directs them if they are assigned to contractors. The PPC performs the coordination function as directed by the TSA and with approval of the TA as required. Figure 3-5 depicts the organizational interfaces.

3.11.3 Training Materials

The SSBN Weapon System training materials include management materials, curriculum materials, and instructional media materials. They do not include the tactical hardware or simulator/stimulator hardware used in training.

3.11.3.1 Management Materials

Management materials define the training requirements and provide an overall plan for accomplishing these requirements. These materials include NAVORD OD 45240, OD 45519, OD 45953, and OD 43180. These documents are developed and supported by the PPC, under the direction of the TSA, reviewed by the program participants, and approved by the TSA.

a. SSBN Weapon System Training Materials Management Plan

OD 45240 consists of two volumes: (1) Producers, and (2) Schedules. This document defines the tasks required to develop and support training materials, identifies the sequence of task performances, establishes task performance responsibilities, and identifies status and development schedules for planning, developing, and supporting training materials.

b. SSBN Weapon System Training Material Development and Production Specifications

OD 45519 consists of three volumes: (1) Introduction and Management Materials, (2) Curriculum Materials, and (3) Instructional Media Materials. This document is the governing specification on all training material acquired for the formal school environment and the informal training environment.

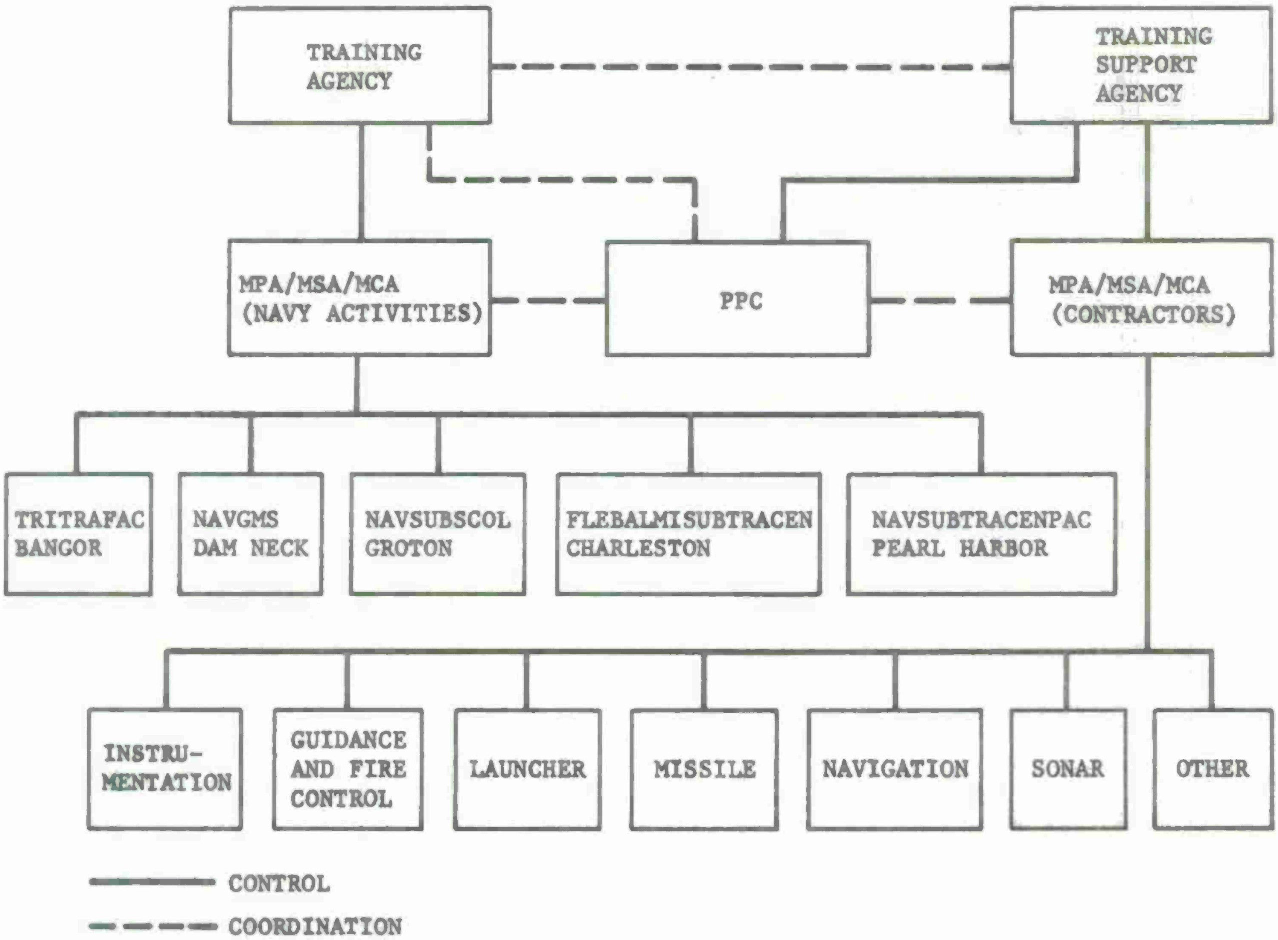

Figure 3-5. SSBN Weapon System Training Material Program Organization

c. FBM Weapon System Personnel and Training Evaluation Program (PTEP)

OD 45953 provides a general description of PTEP and its relationship to other elements in the training program, detailed descriptions of the testing component and the evaluation component of PTEP, and a detailed description of the use of electronic data processing in support of PTEP.

d. FBM Weapon System Personnel Performance Profiles (PPP) and Training Path System (TPS)

OD 43180 consists of the PPP and TPS volumes. The PPP tables are minimum requirements lists of the knowledge and skills required to effectively operate and maintain a system, subsystem, or equipment. The PPP tables are used as a basis for determining training requirements, developing learning objectives in curriculum materials and instructional media materials, and developing personnel evaluation instruments for use in PTEP.

The TPS relates particular knowledge and skill items from the PPP tables to specific categories of Navy personnel in a logical order and to a defined level of knowledge and skill. The TPS consists of three elements: (1) Training Objective Standards (TOS), (2) Training Path Charts (TPC), and (3) Training Level Assignment (TLA). The TPS is used as a basis for determining training requirements, developing learning objectives in curriculum materials and instructional media materials, and developing personnel evaluation instruments for use in PTEP.

TPS development is initiated immediately after the PPP tables are produced and distributed and must be completed before curriculum development begins.

3.11.3.2 Curriculum Materials

Curriculum materials constitute a detailed plan for the presentation of information and practice of skills in the formal training environment as specified by the management materials. A curriculum consists of an Instructor Guide (IG) and a combination of instruction sheets and instructional media materials. The IG is the primary element of every curriculum; it establishes the detailed course learning objectives, sequences the presentation of information, and programs the use of all other curriculum elements.

The TA and TSA coordinate the assignment of the MPA/MSA for curriculum development. The MPA prepares the IGs, the instruction sheets, the supporting instructional media materials, and test item drafts for PTEP. The PPC conducts timely in-process reviews of the curriculum

materials to ensure that they are prepared in accordance with the requirements and specifications found in OD 43180 and OD 45519. TF instructors, with the support of the TA and MPA (if required), verify the curriculum package by conducting pilot courses using the preliminary materials. Verified curriculum materials consist of the preliminary package with the recommended changes incorporated. Final curriculum materials consist of the verified curriculum package approved by the TA. The PPC publishes and distributes the promulgated curriculum materials as directed by the TSA.

3.11.3.3 Instructional Media Materials

Instructional media materials aid in the presentation of information and the practice of skills in both the formal and the informal training environments. These materials include Self-Study Workbooks, slides, Lecture Guides, programmed super 8mm presentations, Administrator Guides, overhead transparencies, or any combination of the above.

The TA and TSA coordinate the assignment of the MPA/MSA. For the most part, instructional media materials are developed by contractor MPAs. The PPC performs the coordination and review function to ensure that the materials are prepared in accordance with the appropriate volumes of OD 43180 and OD 45519. Concurrent approval by the TA and TSA is required for materials used in the formal school environment.

The development procedure for instructional media materials used in the formal school environment is initiated any time after the completion of third stage curriculum materials development. Since most of these materials are changed by revision only, the change procedure is identical to the four stages identified in the development procedure.

3.11.4 Training Materials Support

The Training Materials Support Program provides an effective means of changing training materials to correct deficiencies and errors and to keep them current with changing training requirements and equipment/documentation alterations. The program supports management materials, curriculum materials, and instructional media materials. The two primary functions are surveillance and changes/revisions.

The TSA and TA coordinate the assignment of the MPA, MSA, and MCA. The MSA is responsible for the surveillance of the materials. The MPA and MCA are responsible for minor changes and revisions. The MPA is responsible for major changes and revisions, particularly those that require verification in a pilot course. The MPA, MSA, and MCA may be the same or different organizations. The TSA directs contractor MPAs, MSAs, and MCAs. The TA, in coordination with the TSA, directs Navy

activity MPAs, MSAs, and MCAs. The PPC reviews all recommendations for changes/revisions and provides comments and recommendations to the TSA. The TA approves changes/revisions to curriculum materials and instructional media materials used in the formal school environment.

3.11.4.1 Surveillance

Surveillance is a training materials feedback system designed to keep the training program accurate and current in an environment of changing hardware, operating techniques, and training requirements. Surveillance involves monitoring hardware and documentation changes for impact on the training materials and allows changes to be made to the training materials at the same time or prior to the hardware/documentation changes. The MSA continuously reviews the following sources: (a) new documentation added to the program; (b) changes and revisions to documentation listed in the DRL (Documentation Requirements List) that result from SPALTs (Strategic System Project Alternations), SHIPALTs (Ship Alterations), TERs (Trouble and Failure Reports), TMCRs (Training Materials Change Recommendations), software changes, etc.; and (c) changes and revisions to official documentation promulgated by Navy commands and agencies and new training requirements.

Surveillance results in recommendations for changes or revisions to the training materials. TFRs are submitted by training material users, such as TFs and fleet activities, and TMCRs are submitted by activities other than training material users, such as contractors and the TSA, to indicate deficiencies and make recommendations. The TA/TSA review the TFRs/TMCRs and either approve, approve with exceptions, disapprove, or defer approval on the recommended changes.

3.11.4.2 Changes/Revisions

The change/revision process corrects the deficiencies identified during surveillance. Changes and revisions to management materials and curriculum materials are developed after these materials are promulgated. Changes and revisions to instructional media materials are developed after these materials are distributed for use in the formal school environment. All changes and revisions are reviewed by the PPC to ensure that the material is prepared in accordance with the specifications in OD 45519.

3.12 CBI Courseware Development

After a thorough review of the procedures outlined in OD 45240 for training materials development and support, it was determined that the procedures for CBI courseware development should be included within the procedures for curriculum materials development rather than the procedures for instructional media materials development. The activities and functions identified in the five stages for IG development parallel

the activities and functions necessary to develop CBI courseware. The procedures in the four stages for instructional media materials for the formal environment were not comprehensive enough to include CBI courseware.

Paragraph 3.12.1 discusses the activities and documentation required prior to the start of courseware development. Paragraph 3.12.2 describes the stages for CBI development within the context of the stages for IG development. Paragraph 3.12.3 outlines the specific roles and procedures for CBI courseware development.

3.12.1 Development Prerequisites

It is recommended that the procedure for selecting instructional units to be put on CBI be separated from the procedures for curriculum materials development. The method for SWS CBI Curriculum Selection described in section 2 of this report or an alternate selection methodology can be implemented to serve this function in the future.

By placing this procedure outside the realm of materials development, all aspects of the curriculum will be considered as potential candidates for CBI. The instructional units can be selected from the IG curricula, like the 64.25 CBI hours identified in section 2, or they can be new units earmarked for CBI development only.

In either case, certain documentation requirements must be met prior to the start of courseware development. Technical documentation in the form of equipment specifications, operating procedures, casualty procedures, standard maintenance procedures, etc., and OD 43180 containing the PPP/TPS must be available. If the instructional units are selected from the IG curricula, additional documentation in the form of third, fourth, or fifth stage IGs should also be available. The development schedule for the initial 64.25 CBI hours, as indicated in Figure 3-1, coincides with third stage IG development so this documentation should be input to the courseware development effort.

3.12.2 Development Stages

To identify the stages for CBI courseware development, the activities within each stage of IG development were analyzed. Stage 1 encompasses the initial planning and scheduling and the preparation and review of Stage 1 deliverables. It is recommended that the initial planning and assignment of roles for CBI courseware development be accomplished outside the procedures for curriculum development. Paragraph 3.12.3 discusses the roles and procedures for CBI implementation in detail.

Stage 1 deliverables for IGs include: (a) Curriculum Devleopment Schedule, (b) Course Learning Objectives, (c) Manuscript Outline, (d) Section Learning Objectives and Topic Training Goals, (e) Preliminary OAC (Profile Item-To-Topic Objective Assignment Chart), and (f) Material Requirements List. All of the deliverables, except two, are specific to the IG format. The CBI lesson material will require a Curriculum Development Schedule and a Materials Requirement List, but these can be incorporated into the deliverables for Stage 3.

Stage 2 consists of preparing a representative portion of the IG for review and approval. The proposed CBI implementation schedule shown in Figure 3-1 suggests a phased development effort. By following this strategy, the 10 CBI hours scheduled for FY77 will serve as a representative sample.

Stage 3 involves preparing the IG and supporting materials for use in the pilot course and drafting test items for PTEP. IGs rely upon instructor personalization after design and development and prior to the pilot course to identify discussion points and provide detail, whereas CBI lesson material requires a detailed hierarchy of learning objectives and an instructional strategy format prior to the development effort. As discussed in paragraph 3.8.2.3, the estimate for the number of man-hours required to develop one TRIDENT CBI hour was divided into two components: 50 hours for the analysis and refinement of learning objectives and 200 hours for the design, implementation, debug, validation, and revision. Stage 3 activities for CBI will encompass the analysis, design, implementaion, and debug of lesson material. A CBI Curriculum Development Schedule and Material Requirements List should be delivered at the beginning of Stage 3 for review and approval. The deliverables at the end of Stage 3 should include the CBI courseware (on-line textual material, supporting instructional media material, internal test items, and student response trails) and test item drafts for PTEP.

Stage 4 activities for IG development include a period for instructor personalization and conducting and reviewing the pilot course. Stage 4 for CBI will include pilot testing to validate the courseware. No instructor personalization is required.

Stage 5 is defined as the finalization period for IGs. Approved pilot course changes are incorporated and the curriculum materials are approved and disseminated. The finalization period for CBI will include incorporation of the revisions indicated during the validation process, review and approval, and dissemination procedures.

Based on this analysis, it is recommended that a separate flow for CBI development be established from Stage 3 through Stage 5. Figure 3-6 summarizes the suggested CBI development stages in relationship to the IG development stages.

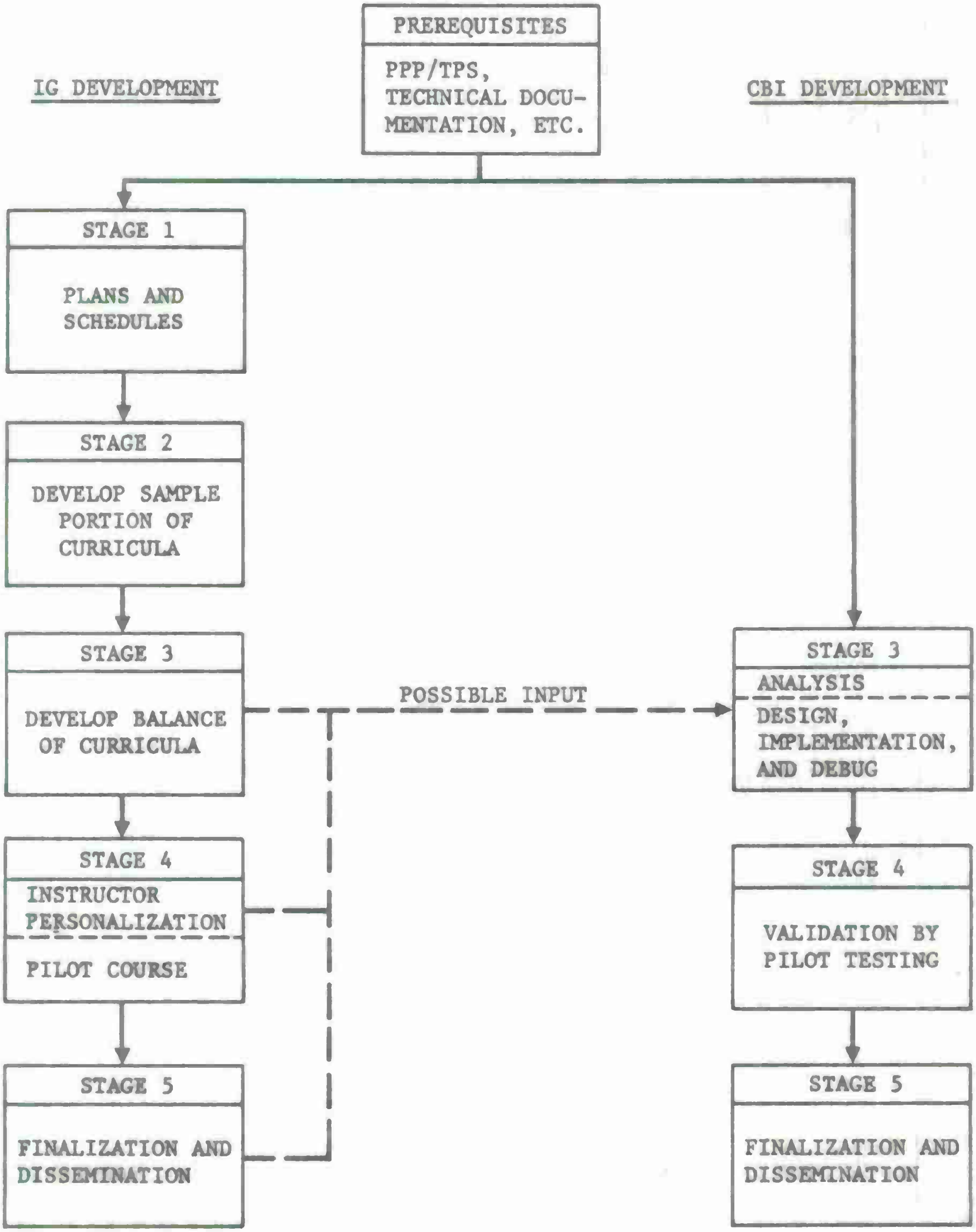

Figure 3-6. Stages for curriculum materials development

3.12.3 Development Roles and Procedures

Figure 3-7 shows the roles and procedures within the five stages of curriculum materials development. Paragraph 3.11.1 provides a definition of the roles shown to the left of the diagram. In order to implement CBI, some of the procedures to be accomplished by each role must be added, deleted, or modified. The following paragraphs identify organizations to perform the roles and describe the procedures for each role.

a. Training Agency/Training Support Agency

The primary functions of the TA/TSA are to provide direction, coordination, and approval authority for the SSBN Weapon System Training Materials Program. The TA is the Chief of Naval Technical Training (CNTT) and the TSA is SP-15. The TA/TSA will be responsible for selecting and prioritizing the instructional units to be put on CBI as well as directing and coordinating the implementation effort.

b. Training Facility

The TF for CBI is TRITRAFAC. TF personnel will be responsible for requisitioning any materials on the Material Requirements List, reviewing the CBI courseware during Stage 3 development, conducting the pilot tests, and teaching/monitoring the finalized CBI lesson material.

c. Personnel Program Coordinator

The PPC for the SSBN Weapon System Training Materials Program is Data Design Laboratories (DDL). The primary function of the PPC is to monitor, review, and distribute curriculum materials in accordance with the specifications in OD 45519. To provide quality assurance and proper distribution of CBI courseware, lesson material specifications and control procedures will have to be established. Potential CBI areas to be monitored by the PPC include:

(1) Reproduction and distribution of the lesson material to the terminals.

(2) Front matter format and security classification.

(3) Method of identifying CBI courseware internally and externally.

(4) Method of indicating changes and revisions to reflect the current status of the courseware.

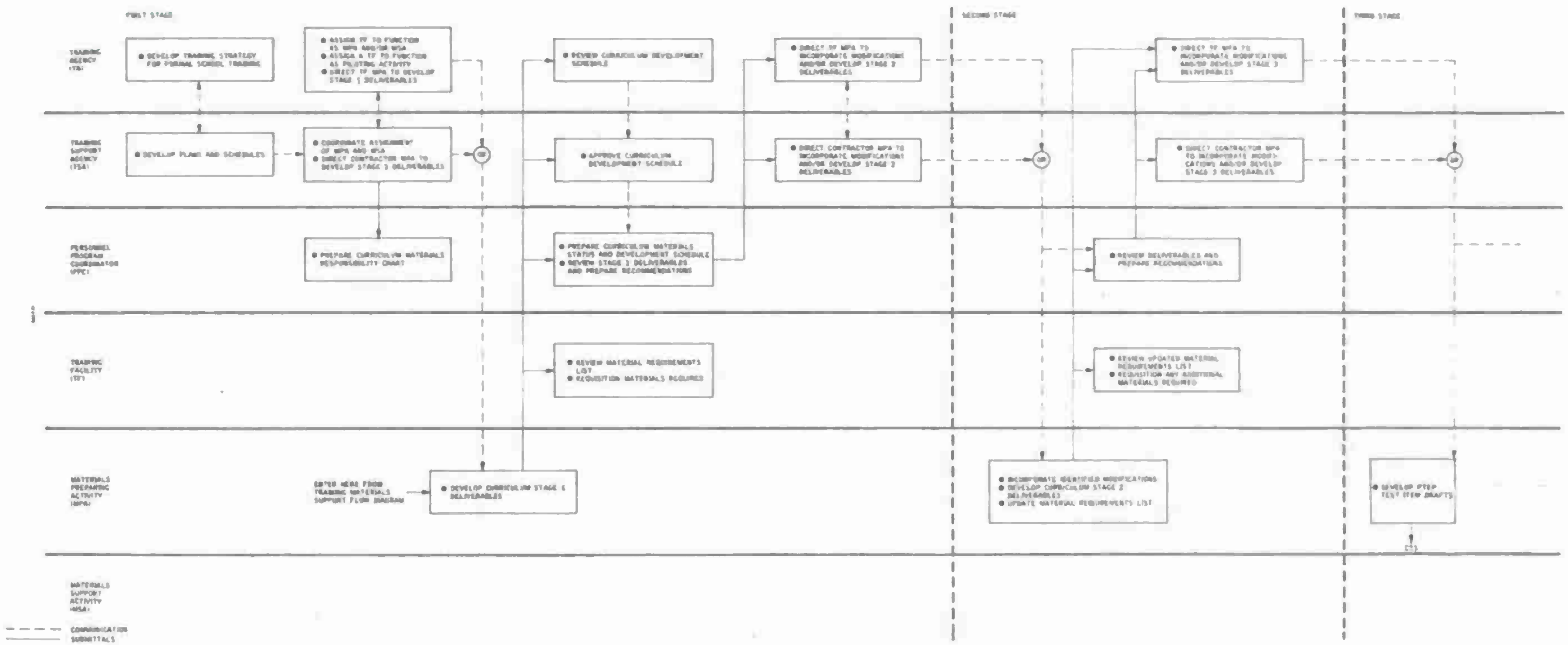

Figure 3-7. Curriculum materials development flow

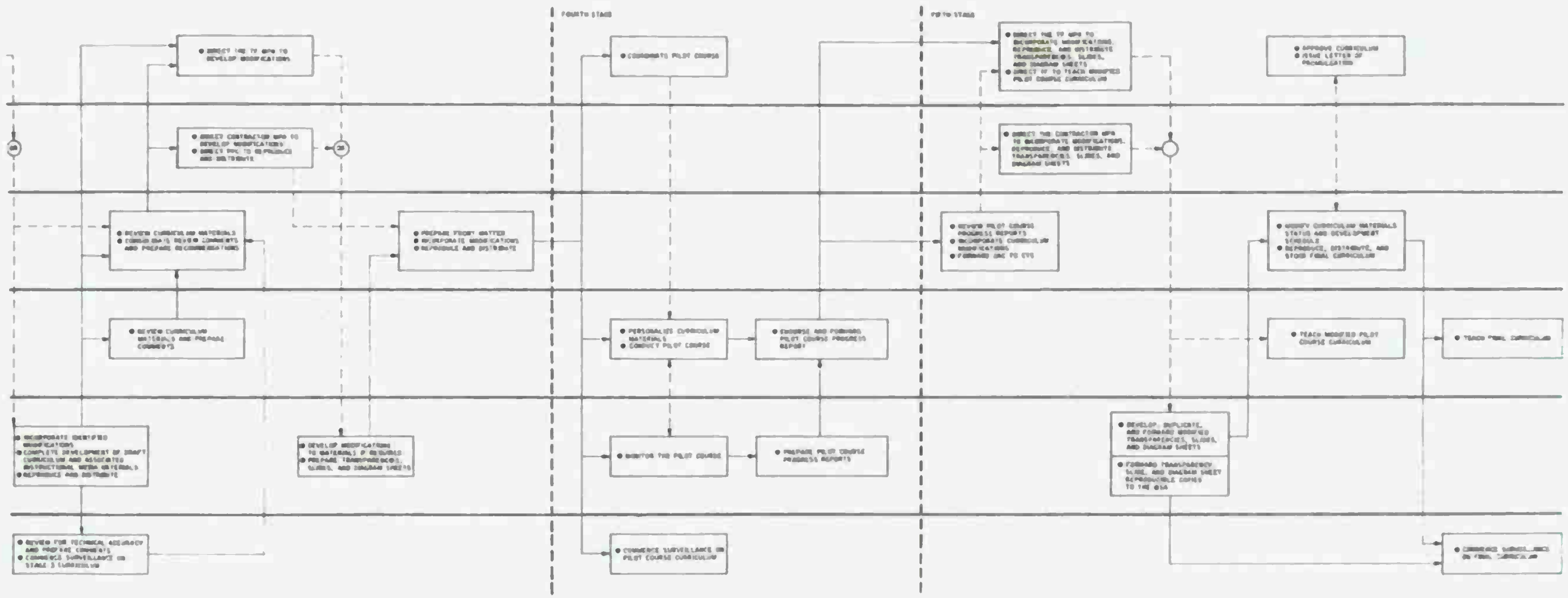

Figure 3-7. (Continued)

(5) Hard copy documentation requirements.

(6) Record of man-hours expended in CBI courseware development and maintenance.

d. Materials Preparing Activity

The MPA will be responsible for CBI courseware development. Tasks to be performed during the development effort include:

(1) Analysis of the technical documentation and IGs, if available, to establish the hierarchy of learning objectives and determine the instructional strategy.

(2) Lesson material design--including such things as simulation techniques to be used, associated media material requirements, and internal test items.

(3) Implementation--including off-line preparation and coding, on-line data entry, debugging for programming errors, editing for technical accuracy, associated media material production on-site or by contractor, and PTEP test item drafts.

(4) Formative and summative validation of lesson material, analysis of student response data, monitoring pilot tests, and revising the lesson material accordingly.

Based on the proposed implementation schedule shown in Figure 3-1, it is suggested that the MPA for the initial development effort be one of the Training Hardware Contractors (THC) with subject matter expertise and experience in developing IGs. After the first few CBI hours are completed and the specifications and roles and procedures for CBI development are finalized, it is suggested that Navy personnel be given MPA responsibility. Activities under the Chief of Naval Education and Training (CNET), if given this task, could make a substantial cost savings over contractor efforts. In addition, the Navy would benefit from the experience of participating personnel, Navy wide.

e. Materials Support Activity

The MSA conducts the surveillance activity described in paragraph 3.11.4.1. For CBI courseware development, it is recommended that the MSA function be expanded and split between several organizations:

(1) DDL as the lead MSA to monitor the implementation effort and provide surveillance for CBI lesson material during Stage 3 development, Stage 4 validation, and Stage 5 revision.

(2) THCs as support MSAs to review Stage 3 courseware for technical accuracy and provide surveillance.

In addition, it is recommended that Navy personnel under the cognizance of CNET monitor the initial CBI implementation effort to provide input to the documentation and gain familiarity with the development process for future participation.

3.13 CBI Courseware Maintenance

Paragraph 3.11.4 provides a brief overview of the Training Materials Support Program. It is an effective system designed to keep management materials, instructional media materials, and curriculum materials current in a changing training environment. The incorporation of CBI into the curriculum materials requires only minor modifications to the established procedures.

3.13.1 Maintenance Roles and Procedures

Figure 3-8 shows the roles and procedures for training materials support. Paragraph 3.11.1 provides a definition of the major roles shown to the left of the diagram. The following paragraphs identify the organizations to perform the major roles and describe the procedural changes, if any, required to implement CBI.

a. Training Agency/Training Support Agency

The TA is CNTT and the TSA is SP-15. The TA/TSA monitor and direct the training material support effort and provide final approval authoring for changes. CBI implementation will not impact these functions.

b. Personnel Program Coordinator

The PPC for the training material support effort is DDL. The review procedures conducted by the PPC do not require modification for CBI courseware maintenance. TFRs and/or TMCRs recommending changes to CBI can be processed within the system as it currently operates.

c. Materials Support Activity

It is recommended that the MSA for training materials support be the same organizations identified in paragraph 3.12.3.e. CBI does not effect the surveillance function; the same sources for documentation and/or hardware changes must be monitored continuously for impact on CBI courseware.

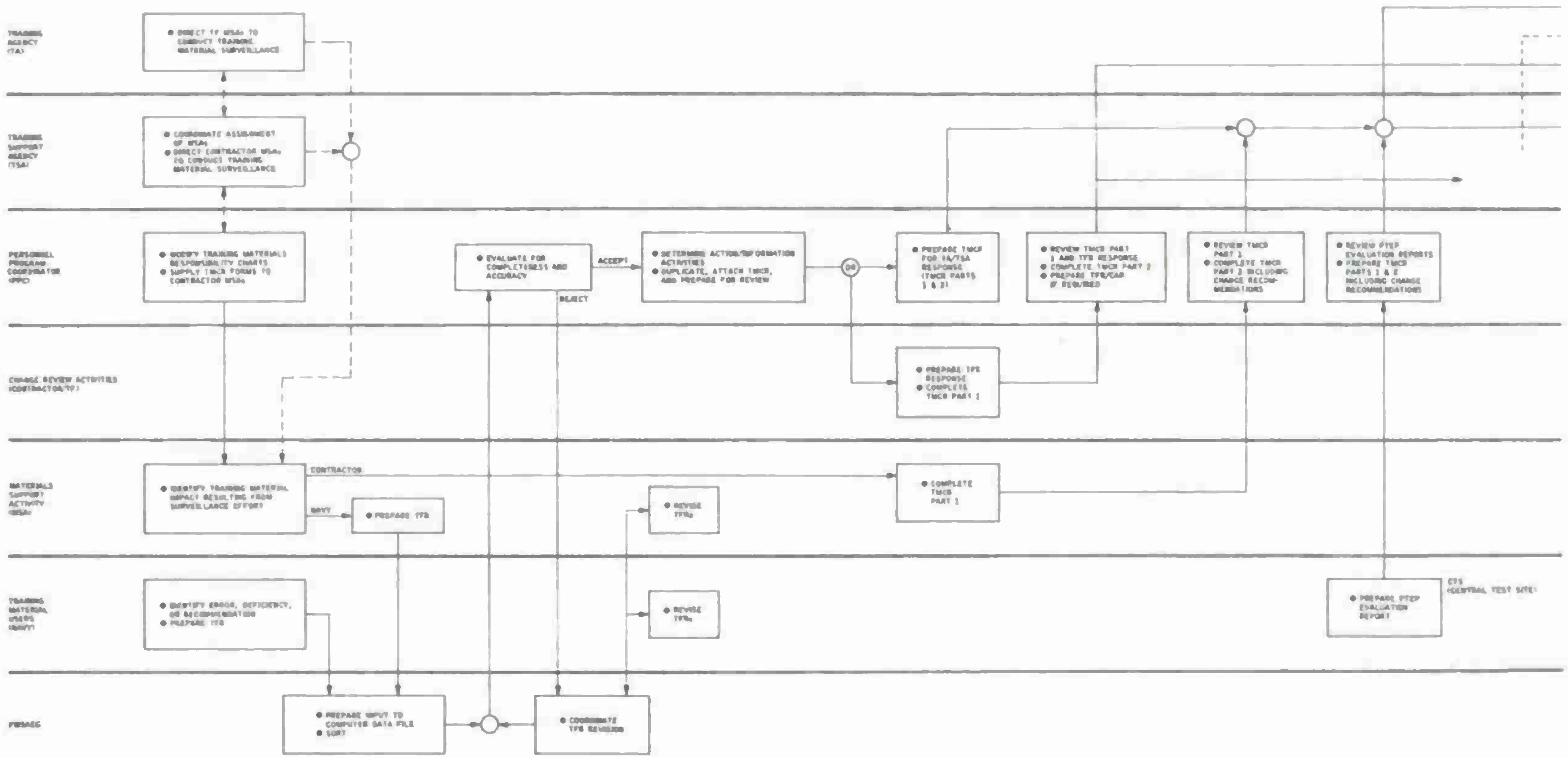

Figure 3-8. Training Materials Support Flow.

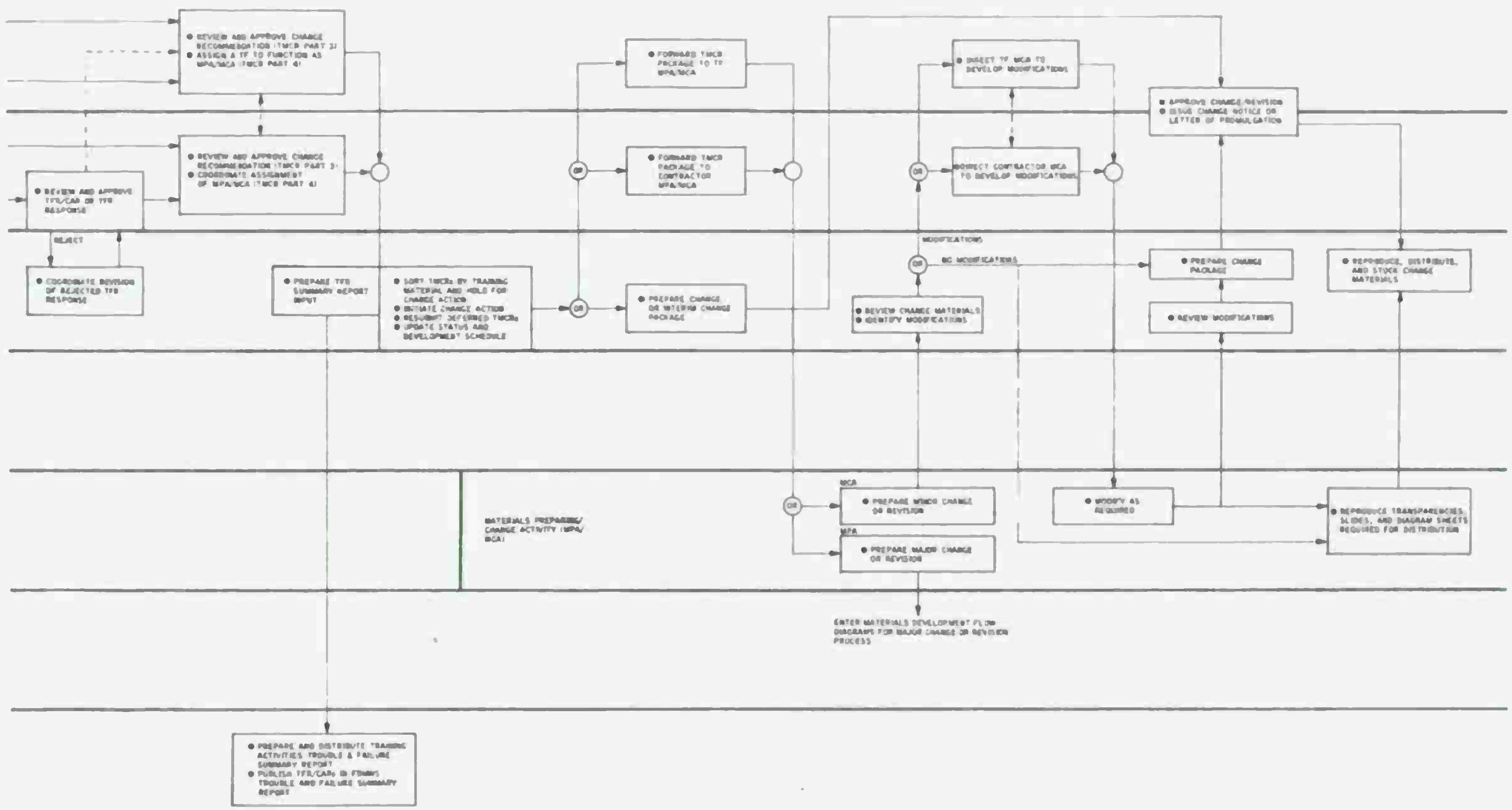

Figure 3-8. (Continued)

d. Materials Preparing Activity/Materials Change Activity

CBI courseware will require major and minor changes. To ensure uniformity and quality assurance, the MPA for major CBI changes and the MCA for minor CBI changes should be the same organization.

It is recommended that Navy personnel located at TRITRAFAC incorporate the required changes to the CBI courseware. A procedure to monitor the number of man-hours expended for maintenance (on a TFR/TMCR basis) should be implemented to determine future staffing requirements. This information should be provided to the PPC to be formatted and forwarded to the TA/TSA upon request.

The procedures to be performed by the activities listed below do not require modification due to the implementation of CBI:

a. Change/Review Activities - it is recommended that this activity be the MPA for CBI courseware development and/or the MPA/MCA for courseware maintenance.

b. Training Material Users - this activity is TRITRAFAC.

c. FMSAEG - this activity is the Fleet Missile Systems Analysis and Evaluation Group responsible for processing TFRs.

3.13.2 Summary

The implementation of CBI requires only minor modifications to the Training Materials Support Program. In order to make CBI an effective training tool, the emphasis on rigorous surveillance and rapid identification on changes cannot be stressed enough. Good communication networks and coordination functions must be established to keep the CBI courseware current in a changing training environment.

3.14 CBI Courseware Documentation

After reviewing the management materials described in paragraph 3.11.3.1, it was determined that only two documents must be revised to incorporate CBI into the FBM Training System: OD 45240, SSBN Weapon System Training Materials Management Plan, and OD 45519, SSBN Weapon System Training Material Development and Production Specifications. OD 43180, FBM Weapon System Personnel Performance Profiles and Training Path System, and OD 45953, FBM Weapon System Personnel and Training Evaluation Program, are not impacted by the implementation of CBI. PPP/TPS are prerequisites for CBI courseware development and PTEP test item drafts are included in the Stage 3 deliverables for CBI.

As discussed in paragraph 3.8.4, it is suggested that the documentation changes be developed in conjunction with the first few CBI hours. Outlining the roles and procedures and defining the specifications for CBI courseware while CBI development is in progress should minimize the revision effort. In this way, problems will be identified and solved prior to finalizing the document. Paragraph 3.14.1 discusses the changes required to OD 45240 and paragraph 3.14.2 provides recommendations for revising OD 45519.

3.14.1 SSBN Weapon System Training Materials Management Plan (OD 45240)

Both volumes of OD 45240 require minor revisions to incorporate CBI. In all cases, the definition of curriculum materials for formal school training must be expanded to include CBI courseware as well as IGs.

Volume 1, Procedures, must reflect the roles and procedures within the stages of CBI courseware development. The recommendations in paragraph 3.12, or an alternate implementation plan, can be used as the basis for a new chapter or a new section in Chapter 4 to describe the CBI development flow.

Volume 2, Schedules, requires a consistent method of designating CBI hours within the NAVTECHTRA course numbers. The Curriculum Materials Responsibility Chart must be updated to include the MPA/MSA assignments for CBI. The Curriculum Materials Status and Development Schedules for CBI must be incorporated into the charts. The Curriculum Allowance List must be revised to include CBI under TRITRAFAC.

3.14.2 SSBN Weapon System Training Material Development and Production Specifications (OD 45519)

OD 45519 consists of three volumes. Volume 1, Introduction and Management Materials, and Volume 3, Instructional Media Materials, do not need to be changed to incorporate CBI into the documentation. However, Volume 2, Curriculum Materials, requires major revision. It is suggested that the current version of Volume 2 be left intact and that an additional volume or an appendix be added for CBI.

The specifications for CBI courseware development and production will come from two sources. One will be the procedures and techniques in the author/user manual for the specific CBI system and the other will be the guidelines developed for OD 45519. Recommended content areas to be covered in OD 45519 CBI specifications include:

a. Criteria and methodology for selecting instructional units to be put on CBI.

b. Documentation requirements (content/format/samples) for:

(1) Learning objectives

(2) Instructional strategies

(3) Simulation techniques

(4) Associated media materials

(5) Validation data

c. Description of authoring process:

(1) Design techniques

(2) Off-line preparation and coding

(3) On-line implementation and debugging

(4) Formative and summative validation procedures

d. Definition of deliverables.

e. Method for recording development and maintenance man-hours.

SECTION 4. PHASE III: CONFIGURATION COST ANALYSIS

4.1 Overview

The first part of this section presents an estimate of the costs to implement CBI for SWS training at TRITRAFAC. The costs are divided into two categories: (a) baseline costs which are associated with the implementation of any CBI system, and (b) the differing costs associated with each specific CBI system which allow cost comparisons among the candidates. The baseline costs encompass the activities, recommended in section 3 to incorporate the roles, procedures, and specifications for CBI into the FBM Training System. The comparative costs consist of life-cycle costs such as purchase, maintenance, and training for each CBI system candidate identified in section 3.

Paragraph 4.2 describes the cost analysis methodology as based on FBM Training System budgeting procedures. Paragraphs 4.3, 4.4, and 4.5 provide a detailed analysis of the life-cycle costs for each of the three system candidates: TICCIT, PLATO, and CBTS, respectively. Paragraph 4.6 compares the life-cycle costs of the three candidates to determine the most cost-effective CBI configuration for meeting SWS training requirements identified in section 2.

Two forms of growth are seen as possible for TRIDENT SWS training. The first growth area is in the amount of laboratory training which may be carried on a CBI system. This growth would be a direct extension of the functional application that is the main subject of this study: simulation of operator or maintenance laboratory training. The second growth area is that of other functional applications for which a computer-based system could be of benefit. The area includes classroom training, computer-managed instruction, the Personnel Training and Evaluation Program, and instruction for low volume or nonperiodic training which may be more cost-effective as self-paced, unscheduled courses. Paragraphs 4.7 and 4.8 address these two growth areas and the possible impacts on SWS training at TRITRAFAC.

4.2 Cost Analysis Methodology

The objective of the cost analysis was to compare the costs of the CBI system candidates identified in section 3 over a 10-year life cycle to determine the most cost-effective CBI system for SWS training at TRITRAFAC. To accomplish this, a framework for analyzing and comparing the costs of the three alternatives was required. Rather than establishing CBI-oriented cost categories for this purpose, the budgetary estimates for each configuration were developed within the FBM Training System Work Breakdown Structure (WBS). By utilizing the WBS as a framework for conducting the cost analysis, several advantages are realized:

a. It serves as a checklist to ensure that all required tasks are scheduled and it indicates the duration of the various tasks as well as the fiscal years in which funds will be expended.

b. It provides a detailed low level breakout of cost elements.

c. It identifies the total cost of end products.

d. The matrix approach provides a cost trade-off model to compare CBI system alternatives on a life-cycle basis.

The WBS is described in the TRIDENT Strategic System Training Concept Document, dated 17 December 1974. The WBS is comprised of training hardware, software, and documentation cost elements. It encompasses the concept, design, production, installation, testing, and support phases of an FBM Training System. The SP-15 approved WBS is shown in Table 4-1. Tasks 0001, 0002, 0003, 0004, and 0008 include the nonrecurring investment costs, while tasks 0005, 0006, and 0007 cover the recurring life-cycle support costs.

For the purpose of this study, Tasks 0001, 0025, 0004, and 0008 were not applicable. Tasks 0001 and 0004 address the overall training system design and installation and specify activities to be performed by the Program Coordinator and PLATO. It has been assumed that the implementation of CBI will impose no additional cost requirements on the services provided by these agencies and, therefore, these tasks were not used. Task 0025 covers the tactical hardware and associated equipment and is not pertinent to CBI. Task 0008 applies to the System Engineering Supervisor only and is not impacted by CBI.

Tasks 0002, 0003, 0005, 0006, and 0007 are relevant CBI cost categories. In order to provide a comprehensive picture of CBI implementation costs, the cost elements within these tasks were specified as either baseline or comparative. Paragraph 4.2.1 discusses the baseline costs required to incorporate CBI into the FBM Training System and paragraph 4.2.2 describes the comparative cost elements that are a function of the CBI system configuration.

4.2.1 Baseline Costs

In accordance with the recommendations in section 3 to incorporate the roles, procedures, and specifications for CBI into the FBM Training System, three potential baseline cost elements were identified from WBS Tasks 0002, 0003, 0005, 0006, and 0007. A brief definition of each element is provided below:

a. 2.03 SCHEDULE, LIAISON, MONITOR
Management activities - scheduling, monitoring, coordination, and reviews required to install the CBI system at TRITRAFAC.

b. 3.04 SCHEDULE, LIAISON, MONITOR
Management activities - scheduling, monitoring, coordination, and reviews required to incorporate CBI courseware into the FBM Training System.

Table 4-1

Work Breakdown Structure Approved by SP-15

FBM TRAINING SYSTEM (SP-15)

WORK BREAKDOWN STRUCTURE (WBS)

M.A. Suffix	TASK	IEOS SSM (W NJ) PC	IEOS SSM (F NJ) TH	CDC FPC	CDC SES	LMSC WEST DEC (M L-I) TH	DDL FPC	PATRO
.10 (WEPS) & .11 (NAV)	0001 SYSTEM DESIGN OMN							
	01 Concepts/Studies	X		X			X	X
	02 Sys.Spec/Sys. Des.	X		X			X	
	03 Sched., Liaison, Monitor	X		X			X	X
	04 Sys. Instn. Design	X						
	05 Sys. Field Service	X		X				
	06 Sys. Manuals	X		X			X	
	07 Sys. Instn. Test Prog/Itro	X		X				
	08 Instn. Subcontractor Spec	X						
.20 (WEPS) & .21 (NAV)	0002 TRAINING HARDWARE/SOFTWARE OPN *(EXCEPT DDL)						*	
	01 Concepts/Studies		X			X	X	
	02 Hardware Specs		X			X	X	
	03 Sched., Liaison, Monitor		X			X		
	04 Eqpt. Instn. Design		X			X		
	05 Eqpt. Design/Supp. Doc		X			X		
	06 Software Dev/Doc		X			X	X	
	07 Hardware Fld. Serv.		X			X		
	08 Instn Test Proc.		X			X		
	09 Eqpt. Manuals		X			X		
	10 Non-Tactical Eqpt. Mfg/QC (Changes)		X			X		
	11 PFM Program		X			X	X	
	12 Initial Spares		X			X		
.25 (WEPS) .26 (NAV)	0025 TACT HARDWARE/TACT TEST EQP INITIAL TACT SPARES/TOOLS/GENERAL PURPOSE TEST EQPT OPN							
.30	0003 PERSONNEL CRITERIA/TNG OMN							
	01 Training Requirements Definition		X			X	X	
	02 Curricula Devel.		X			X	X	
	03 Factory Training		X			X		
	04 Sched. Liaison, Monitor		X			X	X	
	05 Informal Training Materiels		X			X	X	
	06 PTEP Support		X			X	X	
	07 Military Travel							

*EXCEPT DDL

Table 4-1. (Continued)

FBM TRAINING SYSTEM (SP-15)

WORK BREAKDOWN STRUCTURE (WBS)

M.A. Suffix	TASK			GEDS SSM		CDC		LMSC WEST/IEC	DDL	PATAD
				(W N) PC	F N TH	FPC	SES	(M L I) TH	PPC	
.40 (WEPS)	0004	INSTN SUBCONTRACTOR	OPN							
.41 (NAV)		01 Instn Labor		X						
		02 Instn Material		X						
		03 Ripout Labor		X						
.50	0005	LOGISTIC SUPPORT	OPN							
		01 Replenishment Hardware			X			X		
		02 Software Maint. and Update			X			X		
		03 SPALT Procurement			X			X		
		04 Replenishment Spares	**							
.60	0006	PERSONNEL SUPPORT	OMN							
		01 Surveillance & PPP/TPS Maint.			X			X	X	
		02 Formal Trng Mat'l Maint.			X			X	X	
		03 Informal Trng Mat'l Maint.			X			X	X	
		04 Instr Advisory Services			X			X		
		05 PTEP Support			X			X	X	
		06 Military Travel								
		07 Factory Training			X			X	X	
.67		08 Personnel Train./Perf Eval-Notu						X***		
.70	0007	HARDWARE SUPPORT								
		01 Field Service			X		X	X		
		02 Sys. Engineering					X			
		03 Sys. Eng. and Doc. Maint.			X			X		
		04 Instl. Maint. and Support	*							
		05 R&R and Replen. Services			X			X		
.80	0008	DESIGN VERIFICATION AND TEST PROG DEVEL	OMN							
		01 Documentation					X			
		02 Field Service					X			
		03 Test Program					X			
		04 System Studies					X			
		05 Schedule/Liaison Monitoring					X			

* NTA, Public Works, etc. only

** SPCC

*** Applicable to only IEC

c. 6.01 SURVEILLANCE AND PPP/TPS MAINTENANCE

Management activities - coordination, monitoring, and surveillance required to maintain CBI courseware within the FBM Training System

As indicated in paragraph 3.7 of section 3, for the purpose of this study, it has been assumed that the installation of the CBI system will be the joint responsibility of the CBI system contractor, the Weapons Program Coordinator (WPC), and the Facilities Coordinator (FPC). Since the WPC and FPC share major implementation responsibility for TRITRAFAC, it has been assumed that any additional cost requirements associated with the installation of CBI will be a negligible part of the total effort. Any installation costs incurred by the CBI system contractor are specific to the system and reflected in the comparative cost elements. Therefore, WBS element 2.03 was not used in the cost analysis.

Paragraph 3.10 through 3.14 of section 3 described the FBM Training System curriculum development and maintenance procedures and documentation. Recommendations for changes to these procedures and documentation to cover CBI were also made. Table 4-2 summarizes these recommendations, delegating them to WBS elements 3.04 and 6.01, and provides an estimate of the associated costs by fiscal year. All of the cost estimates are based on a rate of $22.00 per man-hour, including salary, overhead and profit, as a current average rate for contracted efforts of this sort.

The estimates for WBS element 3.04 reflect the nonrecurring costs during the first 4 years of the system life cycle. WBS element 3.04 consists of two components: (a) the effort required to develop CBI documentation, and (b) the effort required to develop and implement CBI procedures. In discussing the recommended revisions to the documentation with knowledgeable personnel, a consensus of approximately one man-year of effort was reached and this is reflected in Table 4-2. An effort of 1 man-year per fiscal year across the roles identified in Table 4-2 was also projected to implement the procedures for CBI development.

WBS element 6.01 covers the recurring costs required to control and monitor CBI courseware after it has been developed and is in an operational mode. This effort follows the same level of effort and schedule identified for CBI courseware maintenance in Figure 3-3 in section 3 since this is the period of such recurring costs. That is, after the 64.25 CBI hours are developed, 2 years with a high level of effort are followed by 4 years with a low level of effort. A high support effort is defined as 1 man-year and a low support effort is defined as 1/2 man-year across the roles identified in Table 4-2. The baseline costs for both elements for each fiscal year are included in the cost summary for each CBI candidate in paragraphs 4.3, 4.4, and 4.5.

Table 4-2

Baseline CBI Costs

WBS Element	Recommended Changes	Cost Estimate/ Fiscal Year
3.04	Revisions to documentation	46K/FY 77
	OD 45240 minor changes to Management Plan Volumes OD 45519 addendum or new volume of CBI Specifications	
	Procedures for CBI development	46K/FY 76/7T
	TA/TSA direct and coordinate implementation effort select CBI amenable materials	46K/FY 78 46K/FY 77
	PPC provide quality assurance: - review documentation revisions - review deliverables in accordance with OD 45519 CBI Specifications monitor and control: - distribution and reproduction or courseware - internal and external identification - front matter format and security classification - identification of changes and current status - hard copy documentation requirements - record of man-hours expended	46K/FY 79
	MSA lead activity to monitor implementation effort and provide surveillance support activities to monitor for technical accuracy and provide surveillance CNET to monitor implementation effort and provide input to documentation revisions	
6.01	Procedures for CBI maintenance	46K/FY 80
	TA/TSA direct and coordinate support effort	46K/FY 81
	PPC monitor support effort control changes/revisions	23K/FY 82 23K/FY 83
	MSA lead activitity to monitor support effort and provide surveillance support activities to monitor for technical accuracy and provide surveillance	23K/FY 84 23K/FY 85

4.2.2 Comparative Cost Elements

Table 4-3 identifies the comparative CBI cost elements within WBS tasks 0002, 0003, 0005, 0006, and 0007, and provides a definition of the components within each element. The comparative cost elements were used to evaluate the cost of each CBI system candidate identified in section 3. All of the elements are not applicable to each configuration. However, by using a common matrix, the costing differences for each system are apparent and a cost comparison of the candidates is possible.

The life-cycle costs for TICCIT, PLATO, and CBTS are presented on summary tables in paragraphs 4.3, 4.4, and 4.5, respectively. The format for the life-cycle cost summary is shown in Table 4-4. This table includes both the comparative costs and the baseline costs to implement CBI. Each WBS task was computed, by cost element, over the 10-year life-cycle. Subtotals are provided for the cost elements, within a task, by fiscal year. A total is provided for each cost element over the life cycle in the right-hand column. The first half of the table covers the nonrecurring costs by fiscal year and furnishes a total for all of the nonrecurring cost elements. The second half covers the recurring costs by fiscal year and furnishes a total for all of the recurring cost elements. The last line is a total of the nonrecurring and recurring costs by fiscal year and the highlighted space in the bottom right-hand corner indicates the total cost to implement the CBI configuration.

Table 4-3

Comparative Cost Elements Within WBS Tasks

Cost Element	Cost Element Component
0002 TRAINING HARDWARE/SOFTWARE	
2.04 EQUIPMENT INSTALLATION DESIGN	Compile equipment requirements (power, cooling, cables, etc.), lay out design within TRITRAFAC installation
2.05 EQUIPMENT DESIGN/SUPPORTING DOCUMENTATION	Mechanical design, support and trouble-shooting, provisioning documentation
2.07 HARDWARE FIELD SERVICE	Technical reps to supervise on-site installation and test procedures
2.08 INSTALLATION TEST PROCEDURES	Visual/mechanical inspection and functional/operational testing to assure equipment meets manufacturing and performance specifications
2.09 EQUIPMENT MANUALS	Operating, maintenance, software users' manuals
2.10 NONTACTICAL EQUIPMENT	Purchase and/or lease of CBI system components (hardware and software) - possible line items: CPU — Communications interfaces Memory — Operating System On-line storage — Authoring Language I/O devices — Terminals and options
2.12 INITIAL SPARES	
0003 PERSONNEL CRITERIA/TRAINING	
3.01 TRAINING REQUIREMENTS DEFINITION	Formalize instructional strategy and define learning objectives for CBI courseware
3.02 CURRICULA DEVELOPMENT	Design, implement, debug, validate, and revise CBI courseware (includes production of media support materials)
3.03 FACTORY TRAINING	Provide training to military courseware development personnel in CBI system authoring
0005 LOGISTIC SUPPORT	
5.02 SOFTWARE MAINTENANCE AND UPDATE	On-site systems programmer for software maintenance - software updates provided by CBI system contractor
5.03 SPALT PROCUREMENT	Alternations to CBI system hardware/software
0006 PERSONNEL SUPPORT	
6.02 FORMAL TRAINING MATERIAL MAINTENANCE	Support effort to maintain accuracy of instructional content and correct instructional deficiencies for on-line CBI courseware
0007 HARDWARE SUPPORT	
7.01 FIELD SERVICE	On-call contractor field service or maintenance agreements On-site operational support (military technicians for maintenance and operations) Lease costs (communications lines, computer access, etc.)
7.05 REPAIR/RETURN AND REPLENISHMENT SERVICES	

Table 4-4

Format for Life-Cycle Cost Summary

NON-RECURRING WBS COST ELEMENTS	LIFE-CYCLE										TOTAL
	FY 76/7T	FY 77	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85	
					NONRECURRING						
0002 <u>Training Hardware/Software</u>											
2.04 Equipment Installation Design											
2.05 Equip. Design/Supporting Doc.											
2.07 Hardware Field Service											
2.08 Installation Test Procedures											
2.09 Equipment Manuals											
2.10 Non-Tactical Equipment											
2.12 Initial Spares											
Subtotal											
0003 <u>Personnel Criteria/Training</u>											
3.01 Trng. Requirements Definition											
3.02 Curricula Development											
3.03 Factory Training											
3.04 Schedule, Liaison, Monitor											
Subtotal											
NON-RECURRING COSTS TOTAL											

Table 4-4. (Continued)

WBS COST ELEMENTS	LIFE-CYCLE										TOTAL
	FY 76/7T	FY 77	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85	
RECURRING											
0005 Logistic Support											
5.02 Software Maintenance & Update											
5.03 SPALT Procurement											
Subtotal											
0006 Personnel Support											
6.01 Surveillance & PPP/TPS Maint.											
6.02 Formal Trng. Material Maint.											
Subtotal											
0007 Hardware Support											
7.01 Field Service											
7.05 Repair/Return & Replenishment Services											
Subtotal											
RECURRING COSTS TOTAL											
TOTAL CBI SYSTEM COSTS											

The following assumptions were made in preparing the budgetary estimates for each CBI system configuration:

a. All monetary values are expressed in thousands of dollars.

b. All monetary values are expressed in the form of FY76 constant dollars. Government specified discount rates and cost of living indices are not applied.

c. All cost estimates supplied by CBI system contractors are current at the time of this report and subject to change in the future.

d. The nonrecurring investment costs and the recurring support costs are phased over a 10-year life cycle beginning in FY76 and ending in FY85.

e. The hardware procurement costs for each 13 terminal configuration appear in the column entitled FY77.

f. Contractor personnel will develop the courseware in FY77 and military personnel will develop the courseware in FY78 and FY79. Military personnel will require training in CBI authoring techniques. The cost for this training appears in FY77, although training may not take place until FY78.

g. One fiscal year equals 2080 man-hours.

h. A contractor rate of $22.00 per man-hour and a military rate of $10.00 per man-hour is used.

i. The same formulas are used for courseware development and maintenance for each alternative. The differences in courseware development costs are due to media support requirements.

4.3 TICCIT System Costs

A summary of TICCIT system costs over the projected life-cycle is shown in Table 4-5. A detailed breakdown of the nonrecurring and recurring costs within each WBS task is provided in the following paragraph.

4.3.1 Training Hardware/Software

The budgetary estimates for this task were supplied by the MITRE Corporation. As described in paragraph 3.7.1 of section 3, MITRE is responsible for the system integration required to install TICCIT. This effort includes system documentation and equipment manuals, installation design and test procedures, and support personnel provided on-site during and after system delivery. WBS element 2.07 reflects the costs associated with systems integration. The services covered by WBS elements 2.04, 2.05, 2.08, and 2.09 are included under WBS element 2.07.

Table 4-5

TICCIT System Costs

NON-RECURRING WBS COST ELEMENTS	LIFE-CYCLE										TOTAL
	FY 76/7T	FY 77	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85	
NONRECURRING											
0002 <u>Training Hardware/Software</u>											
2.04 Equipment Installation Design											
2.05 Equip. Design/Supporting Doc.											
2.07 Hardware Field Service		130.00									130.00
2.08 Installation Test Procedures											
2.09 Equipment Manuals											
2.10 Non-Tactical Equipment		270.00									270.00
2.12 Initial Spares		30.00									30.00
Subtotal		430.00									430.00
0003 <u>Personnel Criteria/Training</u>											
3.01 Trng. Requirements Definition		11.00	13.12	14.00							38.12
3.02 Curricula Development		65.00	107.62	114.80							287.42
3.03 Factory Training		25.00									25.00
3.04 Schedule, Liaison, Monitor	46.00	92.00	46.00	46.00							230.00
Subtotal	46.00	193.00	166.74	174.80							580.54
NON-RECURRING COSTS TOTAL	46.00	623.00	166.74	174.80							1010.54

Table 4-5. (Continued)

WBS COST ELEMENTS	LIFE-CYCLE										TOTAL
	FY 76/7T	FY 77	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85	
RECURRING											
0005 Logistic Support											
5.02 Software Maintenance & Update		20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	187.20
5.03 SPALT Procurement											
Subtotal		20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	20.80	187.20
0006 Personnel Support											
6.01 Surveillance & PPP/TPS Maint.					46.00	46.00	23.00	23.00	23.00	23.00	184.00
6.02 Formal Trng. Material Maint.			8.00	29.00	51.40	51.40	25.70	25.70	25.70	25.70	242.60
Subtotal			8.00	29.00	97.40	97.40	48.70	48.70	48.70	48.70	426.60
0007 Hardware Support											
7.01 Field Service		51.20	51.20	51.20	51.20	51.20	51.20	51.20	51.20	51.20	460.80
7.05 Repair/Return & Replenishment Services		5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	45.00
Subtotal		56.20	56.20	56.20	56.20	56.20	56.20	56.20	56.20	56.20	505.80
RECURRING COSTS TOTAL		77.00	85.00	106.00	174.40	174.40	125.70	125.70	125.70	125.70	1119.60
TOTAL CBI SYSTEM COSTS	46.00	700.00	251.74	280.80	174.40	174.40	125.70	125.70	125.70	125.70	2130.14

WBS element 2.10 provides an estimate of the procurement costs for TICCIT. The system configuration, as identified in section 3, includes a main processor, a terminal processor, a graphics system, a video system, and 13 terminals with the light pen option. WBS element 2.12 furnishes an estimate of the cost for initial spares for major system components.

4.3.2 Personnel Criteria/Training

The budgetary estimates for CBI courseware development are based on the information found in section 3. The estimate of 250 man-hours per CBI hour was divided into two components in paragraph 3.8.2.3. WBS element 3.01 represents the 50 man-hours per CBI hour for analysis and refinement of learning objectives (20% of the total effort), while WBS element 3.02 represents the 200 man-hours for design, implementation, debug, validation, and revision of lesson material (80% of the total effort). Also, the costs associated with the media support requirements identified in paragraph 3.8.3.1 are included in WBS element 3.02.

The following formulas were used to derive the cost estimates for TICCIT:

a. WBS element 3.01. Number of courseware development man-hours/FY x $/man-hour = $/FY x 20%

b. WBS element 3.02. Number of courseware development man-hours/FY x $/man-hour = $/FY x 80% + $/media support

c. Media support

(1) For off-line digitized graphics production. 10 man-hours/1 CBI hour x number of CBI hours/FY x $10.00/man-hour = $/FY

(2) For videotape production. $400/minute x 5 minutes/1 CBI hour x number of CBI hours/FY = $/FY

The number of man-hours per fiscal year is shown in Table 3-3 and the number of CBI hours per fiscal year is shown in Figure 3-1. The dollars per man-hour are a function of the organization that will develop the courseware. Based on the recommendations in paragraph 3.12.3.d, a contractor rate of $22.00 per man-hour was used for FY77 and a military rate of $10.00 per man-hour was used for FY78 and FY79.

Courseware, Inc., provided the estimate for WBS element 3.03. Factory training for TICCIT includes an initial workshop and continuing support to courseware development personnel for approximately 6 months. The estimates for WBS element 3.04 were taken from Table 4-2, Baseline CBI Costs.

4.3.3 Logistic Support

MITRE has the charter for TICCIT software development and new software packages are provided to the user at no charge. As identified in paragraph 3.7.1 of section 3, the estimate reflected in WBS element 5.02 covers the cost of a full-time military systems programmer to support the existing software.

MITRE is responsible for the system integration effort required to install TICCIT and the user is responsible for the hardware/software configuration after installation. Therefore, no major alterations are anticipated during the proposed life-cycle and no estimate was prepared for WBS element 5.03.

4.3.4 Personnel Support

The estimate for WBS element 6.01 is the same as in Table 4-2, Baseline CBI Costs. The budgetary estimate for CBI courseware maintenance is based on information found in section 3. The number of man-hours per fiscal year over the projected life-cycle appear in Table 3-4 of that section. Based on the recommendations made in paragraph 3.13.1.d, Navy courseware maintenance participation, a military rate of $10.00 per man-hour was used in the calculations for WBS element 6.02.

4.3.5 Hardware Support

WBS element 7.01 reflects the TICCIT hardware maintenance requirements identified in paragraph 3.7.1 of section 3. The estimate for each fiscal year includes a $20.00 maintenance agreement with Data General and one-and-one-half full-time military technicians at a rate of $10.00 per man-hour. WBS element 7.05 provides an estimate of the yearly costs for non Data General system components.

4.4 PLATO System Costs

A summary of PLATO system costs over the projected life-cycle is shown in Table 4-6. A detailed breakdown of the non-recurring and recurring costs within each WBS is provided in the following paragraphs.

4.4.1 Training Hardware/Software

The budgetary estimates for this task were supplied by Control Data Corporation (CDC). As described in paragraph 3.7.2 of section 3, the marketing policy established by CDC for PLATO provides a full range of installation services that are included in the terminal price. As such, the costs associated with WBS elements 2.04, 2.05, 2.07, 2.08, and 2.12 are covered in WBS element 2.10. WBS element 2.10 shows the procurement costs for 13 PLATO terminals. The price quoted for a basic plasma terminal with a local modem, touch panel, and image projector was $11,650. WBS element 2.09 reflects a nominal charge for users manuals.

Table 4-6

PLATO System Costs

WBS COST ELEMENTS	LIFE-CYCLE										TOTAL
	FY 76/7T	FY 77	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85	
				NONRECURRING							
0002 <u>Training Hardware/Software</u>											
2.04 Equipment Installation Design											
2.05 Equip. Design/Supporting Doc.											
2.07 Hardware Field Service											
2.08 Installation Test Procedures											
2.09 Equipment Manuals		.05									.05
2.10 Non-Tactical Equipment		151.45									151.45
2.12 Initial Spares											
Subtotal		151.50									151.50
0003 <u>Personnel Criteria/Training</u>											
3.01 Trng. Requirements Definition		11.00	13.12	14.00							38.12
3.02 Curricula Development		48.54	64.42	68.71							181.67
3.03 Factory Training		1.10									1.10
3.04 Schedule, Liaison, Monitor	46.00	92.00	46.00	46.00							230.00
Subtotal	46.00	152.64	123.54	128.71							450.89
NON-RECURRING COSTS TOTAL	46.00	304.14	123.54	128.71							602.39

Table 4-6. (Continued)

WBS COST ELEMENTS	LIFE-CYCLE										TOTAL
	FY 76/7T	FY 77	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85	
				RECURRING							
0005 Logistic Support											
5.02 Software Maintenance & Update											
5.03 SPALT Procurement			15.00	20.00	15.00						50.00
Subtotal			15.00	20.00	15.00						50.00
0006 Personnel Support											
6.01 Surveillance & PPP/TPS Maint.					46.00	46.00	23.00	23.00	23.00	23.00	184.00
6.02 Formal Trng. Material Maint.			8.00	29.00	51.40	51.40	25.70	25.70	25.70	25.70	242.60
Subtotal			8.00	29.00	97.40	97.40	48.70	48.70	48.70	48.70	426.60
0007 Hardware Support											
7.01 Field Service		168.46	168.46	168.46	168.46	168.46	168.46	168.46	168.46	168.46	1516.14
7.05 Repair/Return & Replenishment Services											
Subtotal		168.46	168.46	168.46	168.46	168.46	168.46	168.46	168.46	168.46	1516.14
RECURRING COSTS TOTAL		168.46	191.46	217.46	280.86	265.86	217.16	217.16	217.16	217.16	1992.74
TOTAL CBI SYSTEM COSTS	46.00	472.60	315.00	346.17	280.86	265.86	217.16	217.16	217.16	217.16	2595.13

4.4.2 Personnel Criteria/Training

The budgetary estimates for CBI courseware development are based on the information found in section 3. The estimate of 250 man-hours per CBI hour was divided into two components in paragraph 3.8.2.3. WBS element 3.01 represents the 50 man-hours per CBI hour for analysis and refinement of learning objectives (20% of total effort), while WBS element 3.02 represents the 200 man-hours for design, implementation, debug, validation, and revision of lesson material (80% of total effort). Also, the costs associated with the media support requirements identified in paragraph 3.8.3.2 are included in WBS element 3.02.

The following formulas were used to derive the cost estimates for PLATO:

a. WBS element 3.01. Number of courseware development man-hours/FY x \$/man-hour = \$/FY x 20%

b. WBS element 3.02. Number of courseware development man-hours/FY/x \$/man-hour = \$/FY x 80% + \$/media support

c. Media support

(1) For 35mm color slide production. 5 man-hours/1 CBI hour x number of CBI hours/FY x \$10.00/man-hour = \$/FY

(2) For microfiche slide production. \$80.00/master + \$27.00/copy x 12 copies/1 CBI hour x number of CBI hours/FY = \$/FY (microfiche processing prices are based on quotes from CDC)

The number of man-hours per fiscal year is shown in Table 3-3 and the number of CBI hours per fiscal year is shown in Figure 3-1. The dollars per man-hour are a function of the organization that will develop the courseware. Based on the recommendations in paragraph 3.12.3.d, a contractor rate of \$22.00 per man-hour was used for FY77 and a military rate of \$10.00 per man-hour was used for FY78 and FY79.

CDC offers a 2-week hands-on workshop to teach the PLATO system and the TUTOR authoring language at a cost of \$1,100 per student. Because of the proposed personnel build-up and the curriculum support and access assistance provided by CDC, WBS element 3.03 reflects factory training for one student only. The estimates for WBS element 3.04 were taken from Table 4-2, Baseline CBI Costs.

4.4.3 Logistic Support

CDC maintains and updates PLATO software at no additional charge to the user. Software support is part of the monthly computer access charge described in paragraph 4.4.5 below so no estimate was prepared for WBS element 5.02. The estimates for WBS element 5.03 take into consideration additional features now under evaluation by CDC. These proposed

improvements to PLATO include audio capability, hardcopy capability at the installation, and increased multiplexing capability.

4.4.4 Personnel Support

The estimate for WBS element 6.01 is the same as in Table 4-2, Baseline CBI Costs. The budgetary estimate for CBI courseware maintenance is based on information found in section 3. The number of man-hours per fiscal year over the projected life cycle appear in Table 3-4 of that section. Based on the recommendations made in paragraph 3.13.1.d for Navy courseware maintenance participation, a military rate of $10.00 per man-hour was used in the calculations for WBS element 6.02.

4.4.5 Hardware Support

Due to laboratory scheduling, a 13 terminal configuration was recommended in paragraph 2.8.4 of section 2. For PLATO, the thirteenth terminal would serve as a back-up or replacement terminal for the 12 on-line terminals. Therefore, all monthly charges are based on a 12 terminal configuration. The costs for repair/return and replenishment are included in WBS element 7.01 under the monthly terminal maintenance charge and no further sum is shown in WBS element 7.05. As identified in paragraph 3.7.2 of section 3, the costs reflected in WBS element 7.01 for each fiscal year consist of five components:

a. Computer access charge of $600.00 per terminal per month for 12 terminals (this includes access for 16 hours/day for 5 days/week, on-call access assistance, and 1,120,000 characters of on-line storage.

b. Terminal maintenance charge of $165.00 per terminal per month for 12 terminals (this includes the plasma terminal, local modem, touch panel, and image projector).

c. Multiplexor service charge of $525.00 per 4X multiplexor per month for three 4X multiplexors.

d. Monthly telephone line charge for three dedicated lines of 1,000 miles each at $.95 per mile (this distance is based on a CDC West Coast PLATO installation planned for 1976).

e. Military technician for one-quarter man-year at a rate of $10.00 per man-hour.

4.5 CBTS System Costs

A summary of CBTS system costs over the projected life-cycle is shown in Table 4-7. A detailed breakdown of the nonrecurring and recurring costs within each WBS task is provided in the following sections.

Table 4-7

CBTS System Costs

WBS COST ELEMENTS	LIFE-CYCLE										TOTAL
	FY 76/7T	FY 77	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85	
				NONRECURRING							
0002 Training Hardware/Software											
2.04 Equipment Installation Design		23.00									23.00
2.05 Equip. Design/Supporting Doc.		12.00									12.00
2.07 Hardware Field Service		11.00									11.00
2.08 Installation Test Procedures		9.00									9.00
2.09 Equipment Manuals		50.00									50.00
2.10 Non-Tactical Equipment		439.00									439.00
2.12 Initial Spares		21.00									21.00
Subtotal		565.00									565.00
0003 Personnel Criteria/Training											
3.01 Trng. Requirements Definition		11.00	13.12	14.00							38.12
3.02 Curricula Development		44.50	53.81	57.40							155.71
3.03 Factory Training		7.00									7.00
3.04 Schedule, Liaison, Monitor	46.00	92.00	46.00	46.00							230.00
Subtotal	46.00	154.50	112.93	117.40							430.83
NON-RECURRING COSTS TOTAL	46.00	715.50	112.93	117.40							991.83

Table 4-7. (Continued)

RECURRING WBS COST ELEMENTS	LIFE-CYCLE										TOTAL
	FY 76/7T	FY 77	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85	
					RECURRING						
0005 Logistic Support											
5.02 Software Maintenance & Update											
5.03 SPALT Procurement			15.00	20.00	15.00						50.00
Subtotal			15.00	20.00	15.00						50.00
0006 Personnel Support											
6.01 Surveillance & PPP/TPS Maint.					46.00	46.00	23.00	23.00	23.00	23.00	184.00
6.02 Formal Trng. Material Maint.			8.00	29.00	51.40	51.40	25.70	25.70	25.70	25.70	242.60
Subtotal			8.00	29.00	97.40	97.40	48.70	48.70	48.70	48.70	426.60
0007 Hardware Support											
7.01 Field Service		10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	10.40	93.60
7.05 Repair/Return & Replenishment Services		4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	39.60
Subtotal		14.80	14.80	14.80	14.80	14.80	14.80	14.80	14.80	14.80	133.20
RECURRING COSTS TOTAL		14.80	37.80	63.80	127.20	112.20	63.50	63.50	63.50	63.50	609.80
TOTAL CBI SYSTEM COSTS	46.00	730.30	150.73	181.20	127.20	112.20	63.50	63.50	63.50	63.50	1601.63

4.5.1 Training Hardware/Software

The budgetary estimates for this task were supplied by General Electric Ordnance Systems (GEOS). Since CBTS is a prototype, certain development costs are incurred by the user for production terminals. WBS element 2.04 covers the costs for facility and arrangement drawings necessary to install the terminals at TRITRAFAC. WBS element 2.05 includes the costs to develop the System Reference Manual and the provisioning parts list for the installation. The estimate for WBS element 2.07 reflects the costs for GEOS engineers to physically install the terminals and to perform visual and mechanical inspections for quality conformance, while WBS element 2.08 covers the functional/operational testing to ensure the terminals comply with performance specifications. GEOS will provide a Student Manual, an Author's Guide, and a Preventative Maintenance Manual for each terminal. The estimate in WBS element 2.09 covers this documentation.

WBS element 2.10 reflects the procurement costs for 13 stand-alone terminals and two portable authoring models. Each terminal consists of a plasma display, floppy disk storage, operator interface via a graph pen or a standard keyboard with six special function keys, and 35mm rear projection capability. The price per terminal is $29,000; however, an additional $4,000 per terminal is shown for a dual display color CRT option. Each authoring module consists of a second floppy disk, an alphanumeric printer, and a working file buffer module. The price per authoring module is approximately $5,000. The estimate in WBS element 2.12 covers the cost for a complete set of terminal components and each unique module type.

4.5.2 Personnel Criteria/Training

The budgetary estimates for CBI courseware development are based on information and recommendations found in section 3. The estimate of 250 man-hours per CBI hour was divided into two components in paragraph 3.8.2.3. WBS element 3.01 represents the 50 man-hours per CBI hour for analysis and refinement of learning objectives (20% of total effort), while WBS element 3.02 represents the 200 man-hours for design, implementation, debug, validation, and revision of lesson material (80% of the total effort). Also, the costs associated with the media support requirements identified in paragraph 3.8.3.3 are included in WBS element 3.02.

The following formulas were used to derive the cost estimates for CBTS:

a. WBS element 3.01. Number of courseware development man-hours/FY x $/man-hour = $/FY x 20%

b. WBS element 3.02. Number of courseware development man-hours/FY x $/man-hour = $/FY x 80% + $/media support

c. Media support

For 35mm color slide production. 5 man-hours/1 CBI hour x number of CBI hours/FY x $10.00/man-hour = $ FY

The number of man-hours per fiscal year is shown in Table 3-3 and the number of CBI hours per fiscal year is shown in Figure 3-1. The dollars per man-hour are a function of the organization that will develop the courseware. Based on the recommendations in paragraph 3.12.3.4, a contractor rate of $22.00 per man-hour was used for FY77 and a military rate of $10.00 per man-hour was used for FY78 and FY79.

GEOS will offer a 2-week orientation course/training session on CBTS authoring. The estimate in WBS element 3.03 includes the preparation and presentation of such a course to courseware development personnel. The estimates for WBS element 3.04 were taken from Table 4-2, Baseline CBI Costs.

4.5.3 Logistic Support

No support is provided in WBS element 5.02. The software structure for CBTS is such that many of the traditional functions are embedded in the hardware modules. GEOS will maintain the software through use of a maintenance diskette to run diagnostic tests and identify failed modules. Any updates to the high-level authoring language will be provided to the user by GEOS.

The estimates in WBS element 5.03 take into consideration options that are under evaluation by GEOS. Potential improvements to CBTS might be hook-up to a central computer directly or by modem, use of a touch panel, a supervisor's monitoring station, and videotape input.

4.5.4 Personnel Support

The estimate for WBS element 6.01 is the same as in Table 4-2, Baseline CBI Costs. The budetary estimate for CBI courseware maintenance is based on information found in section 3. The number of man-hours per fiscal year over the projected life-cycle appear in Table 3-4 of that section. Based on the recommendations in paragraph 3.13.1.d for Navy courseware maintenance participation, a military rate of $10.00 per man-hour was used in the calculations for WBS element 6.02.

4.5.5 Hardware Support

GEOS will support CBTS with the software maintenance diskette and the hardware maintenance panel under an existing facility support contract.

WBS element 7.01 reflects the cost each fiscal year for a military technician one half of the time to perform preventative maintenance and other miscellaneous functions identified in paragraph 3.7.3 of section 3. WBS element 7.05 is an estimate of the cost to return failed modules to GEOS for repair or for replenishment spares.

4.6 CBI System Cost Comparisons

In paragraphs 4.3, 4.4, and 4.5 the costs and cost derivation methods for TICCIT, PLATO, and CBTS, respectively, were presented. It is the purpose of this paragraph to compare the costs of the three system candidates. The final goal, resulting from such a comparison, is to make a recommendation concerning which system is best suited and most cost-effective in meeting TRIDENT SWS laboratory training requirements.

Paragrah 4.6.1 compares the nonrecurring and recurring costs for the three CBI system candidates. Within each of these two broad categories, the specific WBS tasks and the corresponding cost elements are discussed. Finally, the total costs for each of the three systems over a life cycle of 10 years are compared.

In addition, paragraph 4.6.2 examines the relative system costs under conditions other than those defined for TRIDENT SWS laboratory training in this study. The purpose of this paragraph is to provide, in fairness to each system, a more encompassing framework to discuss cost-effectiveness. It will be noted that it is not reasonable to generalize, for all CBI situations, about the costs of a stand-alone terminal versus either a minicomputer or network system based only on the methodology of this study.

4.6.1 Life-Cycle Cost Comparisons

In order to provide a useful summary of life-cycle costs for each system, the fiscal year costs have been collapsed, by cost element, across all 10 years. This allows comparison of cost elements within a task over the total life of the program at a glance. The prime differentiating factor of the comparisons is recurring and nonrecurring costs and each task is in one of these categories. Table 4-8 presents these costs in thousands of dollars and the following paragrahs describe the comparisons.

4.6.1.1 Nonrecurring Cost Comparisons

WBS task 0002, Training Hardware/Software, and WBS task 0003, Personnel Criteria/Training, include all nonrecurring cost elements. The nonrecurring costs, related to one-time charges for initial acquisition and implementation of the CBI systems, are a function of the characteristics and marketing policy of each system, as can be seen in Table 4-8. The costing differences between systems were described in earlier sections.

Table 4-8

Comparative Cost Analysis by WBS Task

WBS COST ELEMENTS	CBI SYSTEM ALTERNATIVES		
	TICCIT	PLATO	CBTS
NONRECURRING			
0002 TRAINING HARDWARE/SOFTWARE			
2.04 Equipment Installation Design			23.00
2.05 Equip. Design/Supporting Doc.			12.00
2.07 Hardware Field Service	130.00		11.00
2.08 Installation Test Procedures			9.00
2.09 Equipment Manuals		.05	50.00
2.10 Non-Tactical Equipment	270.00	151.45	439.00
2.12 Initial Spares	30.00		21.00
Subtotal	430.00	151.50	565.00
0003 PERSONNEL CRITERIA/TRAINING			
3.01 Trng. Requirements Definition	38.12	38.12	38.12
3.02 Curricula Development	287.42	181.67	155.71
3.03 Factory Training	25.00	1.10	7.00
3.04 Schedule, Liaison, Monitor	230.00	230.00	230.00
Subtotal	580.54	450.89	430.83
NONRECURRING COSTS TOTAL	1010.54	602.39	991.83

Table 4-8. (Continued)

WBS COST ELEMENTS	CBI SYSTEM ALTERNATIVES		
	TICCIT	PLATO	CBTS
RECURRING			
0005 LOGISTIC SUPPORT			
5.02 Software Maintenance & Update	187.20		
5.03 SPALT Procurement		50.00	50.00
Subtotal	187.20	50.00	50.00
0006 PERSONNEL SUPPORT			
6.01 Surveillance & PPP/TPS Maint.	184.00	184.00	184.00
6.02 Formal Trng. Material Maint.	242.60	242.60	242.60
Subtotal	426.60	426.60	426.60
0007 HARDWARE SUPPORT			
7.01 Field Service	460.80	1516.14	93.60
7.05 Repair/Return and Replen.	45.00		39.60
Subtotal	505.80	1516.14	133.20
RECURRING COSTS TOTAL	1119.60	1992.74	609.80
CBI SYSTEM COSTS TOTAL	2130.14	2595.13	1601.63

In WBS task 0002, as might be expected, the system with the most experience and developmental history has the least cost related to documentation, manuals, and hardware support. PLATO reflects no costs in elements 2.04, 2.05, 2.07, 2.08, and 2.09 which cover these areas. TICCIT on the other hand, being a relatively new system, requires more field service in order to integrate the separate components for each new system. CBTS represents the other end of the development scale. It is completely new and has not been put into field service yet, and therefore, there are various forms of documentation and installation/checkout costs which are necessary.

In addition, cost differences can be noted in WBS elements 2.10 and 2.12. These two elements cover the procurement costs for terminals and associated support components. For PLATO, these costs include terminals only. For TICCIT, the costs represent the complete system including CPUs, terminals, display generators, and peripherals. For CBTS, the costs include 13 self-contained terminals, processors and display units. PLATO is, again, the least expensive since there are fewer components at less cost with more production history.

In WBS task 0003 the differences are not as large. Element 3.01, Training Requirements Definition, is a baseline cost equal for all systems. Element 3.02, Curricula Development, differs because of associated media costs, such as video tape, microfiche, and slides, rather than the CBI authoring per se. Here TICCIT is the most expensive because of videotape production. It has been assumed that 5 minutes of videotape per hour of CBI would be implemented. Such developmental costs are relatively high compared to microfiche and slides. Factory Training, element 3.03, is also more expensive for TICCIT because there is no "factory" training. An intensive on-site training effort is necessary to train personnel in the learner control method of authoring. There are no differences in element 3.04 because scheduling, liaison, and monitoring are baseline activities with equal costs for all systems.

To summarize the nonrecurring costs, PLATO is easily the least expensive CBI system for TRIDENT SWS training requirements as defined in this study. The main difference in the PLATO costs is in the procurement of the hardware/software and in the documentation/installation support.

4.6.1.2 Recurring Cost Comparisons

Recurring costs for each system are shown on the second half of Table 4-8. There are three WBS tasks within this category: (a) Task 0005, Logistic Support; (b) Task 0006, Personnel Support; and (c) Task 0007, Hardware Support. Task 0006 covers baseline activities that are not a function of the CBI system. There are no differences among the system candidates for these cost elements.

Task 0005 represents the logistic support necessary for software and hardware. This support may be the result of either inherent problems in the system software or hardware changes resulting in additions or improvements. The main difference in costs under this category is in the software maintenance and update projected for TICCIT. Currently, the software requires a lot of support due to new system development and design of TICCIT. While CBTS is also new, the same costs are not expected because many software functions are performed by the hardware so the system software is relatively simple.

The biggest cost differences between the three systems, however, are in WBS task 0007. This recurring hardware support category definitely separates CBTS from TICCIT and PLATO as the least expensive system for TRIDENT SWS training. Element 7.01, Field Service, is the major cost difference. While PLATO appeared relatively cost-effective in the tasks described above, the system now becomes much more expensive. For PLATO, element 7.01 includes monthly computer access charges, maintenance charges, and telephone line charges. These recurring costs are specific to the PLATO architecture--a large network system handling many terminals--and they are not required for TICCIT and CBTS. TICCIT is also much more expensive than CBTS. For TICCIT, element 7.01 includes a yearly maintenance agreement for major system components as well as full-time on-site personnel to maintain other system components and perform operator functions. These recurring costs are specific to the TICCIT minicomputer configuration and do not apply to the CBTS stand-alone terminal configuration.

4.6.1.3 Cost Comparison Summary

Figure 4-1 graphically illustrates the nonrecurring costs for PLATO, TICCIT, and CBTS over the projected 10-year life cycle. Of the three candidates evaluated, CBTS is the most cost-effective system to meet the training requirements as defined in this study. In section 3, CBTS was also judged to be the best system in functional capabilities to meet the training requirements. The decision for selecting a CBI system seems clear. Given the criteria that the CBI system must meet the training requirements in a cost-effective manner, CBTS is the recommended candidate for TRIDENT SWS training.

4.6.2 Cost Comparison Generalizations

The costs presented here were based on the requirement, as defined in this study, to alleviate laboratory overloads for TRIDENT SWS training. Care should be taken in generalizing the results and recommendations across other training requirements. The results here should not be taken as an indictment of any CBI system. These results are case specific to the needs of SWS laboratory training.

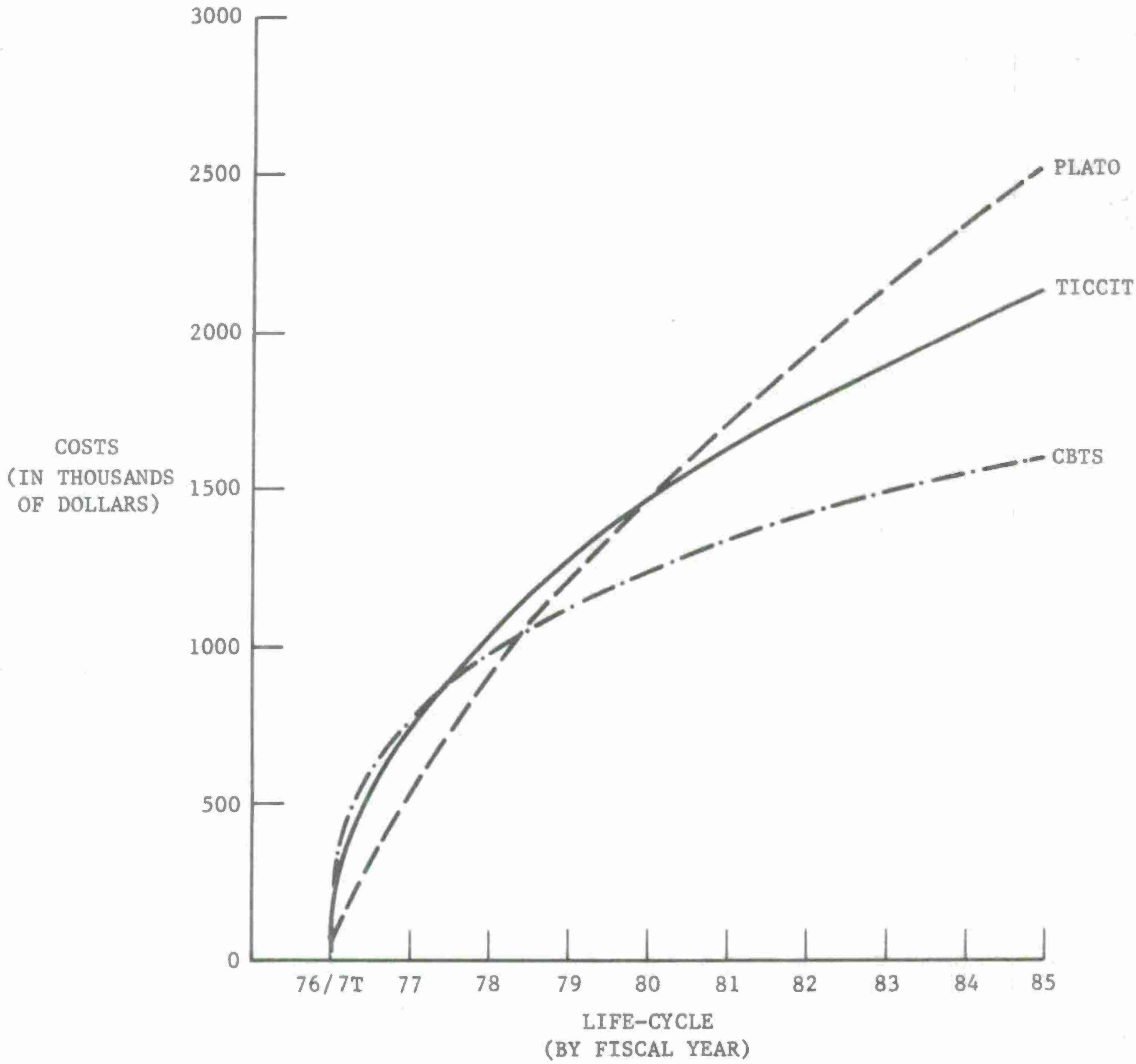

Figure 4-1. Comparative cost analysis over system life cycle.

To illustrate this further, a graph has been prepared which represents the costs under conditions other than those determined in this study. In particular, the graph demonstrates the resulting costs when the number of terminals increases from the 13 projected for SWS training at TRITRAFAC to 24, 32, 64. These costs reflect only the nonrecurring ring procurement costs in WBS element 2.10, Non-Tactical Equipment.

As Figure 4-2 illustrates, PLATO now becomes more expensive than TICCIT with up to 64 terminals. It should be noted, however, that this trend could possibly reverse again if the number of terminals is carried out to 200, 500, or 1000 because PLATO is prepared to handle these larger numbers; whereas, a complete TICCIT system must be purchased for every 128 terminals since that is its maximum capability. It should be noted that CBTS system costs increase sharply when compared to the other two systems as the number of terminals increases. The reason is simple. Both PLATO and TICCIT are designed to control a larger number of terminals than the 13 required for TRITRAFAC SWS training. It is in the larger terminal requirements that they become cost-effective systems.

It should also be noted that Figure 4-2 illustrates costs for only one element. To obtain a more complete costing picture, it would be necessary to take into account many other cost factors, including number and distances of terminal sites, purchase of a complete PLATO system, purchase versus lease of terminals, total personnel support, and amount of courseware development.

4.7 CBI System Growth for Laboratory Training

The number of CBI courseware hours recommended for implementation in section 2 were predicated on projected laboratory maintenance downtime and laboratory scheduling problems. The hours allocated for these two activities were considered to be liberal and not representative of lost laboratory training time. Instead they represented a cushion for training time in the laboratory beyond the 2,526 hours per year determined available. However, this is a judgment and TRITRAFAC experience may show this is not the case. Sufficient time will be available to identify the need for more CBI hours in the three overloaded laboratories and to evaluate the CBI training requirements. Records of maintenance and scheduling should be monitored to allow a rational and experience-based decision if this occurs. Recommendations for additional CBI amenable topics beyond the 64.25 hours suggested for immediate development were presented in section 2.

It is also possible that CBI should be implemented for Navigation Training. An analysis of Sperry supplied data on student throughput and projected utilization factors may indicate overloads in the Navigation laboratories that could be alleviated by CBI. Such an analysis was beyond the scope of this study, but it might be necessary in the future.

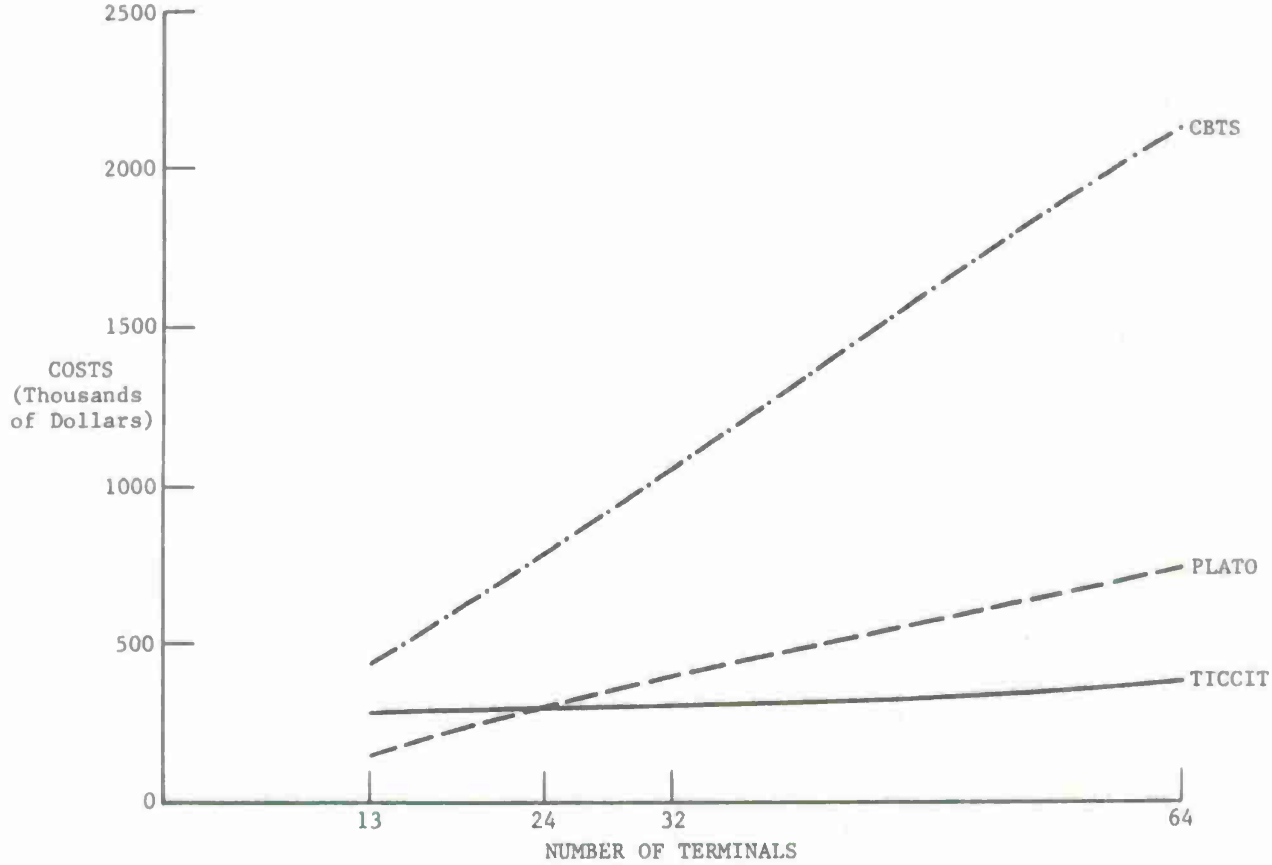

Figure 4-2. Cost impact of increasing the number of terminals

There are other factors inherent in the TRIDENT program which could increase the number of CBI hours required for SWS laboratory training at TRITRAFAC. For example, if more TRIDENT SSBNs are built or SSBN deployment schedules change the training laboratories could be affected. If such events occur CBI system utilization will need to be re-evaluated.

Additional terminals, or other hardware/software components, are probably not required for potential growth. This is because the terminals will be under-utilized as demonstrated in section 2, after the 64.25 CBI hours are developed. The factors driving the number of terminals were the size of a replacement class, 12 students, and the desire not to disturb scheduling by breaking a class up for CBI. It should be possible to schedule a great deal more CBI on the 12 terminals.

4.8 CBI System Growth for Other Functional Applications

Listed in order of importance and coverage in this section, the possible growth of new functional applications are: (a) classroom training, (b) computer-managed instruction across all SWS training, (c) instruction and instructional management of low volume courses, and (d) support of the Personnel Training and Evaluation Program (PTEP). Of these, the last two offer equal potential and the most benefit to TRIDENT SWS training.

4.8.1 Classroom Training

A variety of media are used in SWS classroom training--including text references, slides, audio, and films. Therefore, there is reason to believe that CBI could also be used as an adjunct media to classroom training. CBI could be used for such purposes as introductions, reviews, drill-and-practice, summaries, and testing. However, the application of CBI as an adjunct to classroom training is probably a lower payoff area than the other possible functional applications.

4.8.2 Computer-Managed Instruction

The purpose of computer-managed instruction (CMI) would be to monitor, test, diagnose, and prescribe a student's instruction. CMI is especially useful in an individualized instructional environment. However, most instruction at TRITRAFAC, including the replacement training courses selected for CBI in this study, are necessarily lockstep because they are a combination of classroom and laboratory training in which scheduling is necessary to achieve desired training times. The savings obtained by CBI can be significant in terms of student time (possibly 30% reduction in time to train over all students), decreased instructor ratios, and increased proficiency. Therefore, CBI should be looked into further at a later time in the TRIDENT training program. There are, however, some areas where CMI could be used immediately. These are in low volume courses discussed next.

4.8.3 Instruction and Management of Low Volume Courses

Most training at TRITRAFAC has a sufficient volume of students planned and scheduled to determine complete classes. This is true of most replacement, advanced, and conversion training. However, there are other lower volume training areas, such as officer and possibly some intermediate level maintenance training, where students may not be as predictable for entry dates or numerous enough to establish, cost-effectively, a "class."

In particular, the introduction of TRIDENT SSBNs presents a new problem to SWS training. That is, the possibility of having to train personnel from TRIDENT or POSEIDON C-4 and D-5 programs in another one of the same programs. In these cases, the amount and type of training will vary by experience of the student.

One possible way to handle such cases is through a combination of CMI and CBI simulation or tutorials. By doing so, the individuals will not require special classes per se, can be monitored and managed with less expense than by assignment of instructors in many cases, and should take less time to train becuase the instruction can be designed to take into account what the student already knows.

4.8.4 Personnel and Training Evaluation Program

PTEP, as one of the major elements in the FBM Weapon System Training Program, is the means by which the reset of the program is evaluated. There are three major elements within PTEP: (a) testing, (b) non-test data collection for validity studies and crew evaluation, and (c) evaluation of both test and nontest data. The evaluations then allow external reports to be generated which assist commands in increasing personnel performance capabilities and implementing improvements to the training program.

The main area where CBI can be of benefit in PTEP appears to be the testing element. Testing is currently supported by EDP equipment, but this could be improved. Knowledge tests and some skill tests could be given by a CBI system and graded immmediately. Currently, the tests are administered with paper and pencil and test item responses are fed to a central site via teleprocessing from optical scanning devices.

In the case of Course Achievement Tests (CATS), used to measure trainee comprehension in a given course, instructors currently must use a manual key to determine the score for a student immediately. CBI can accomplish this function without requirements on the instructor's time to provide immediate feedback to the student and instructor. Furthermore, test versions can be generated by the CBI system if desired.

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APPENDIX

FCSU HOURS SELECTED FOR CBI

FCSU Hours Selected for CBI

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
CONTROL AND DISPLAY SUBSYSTEM (CDSS)					
01 (3 hrs)	1.1 Perform normal operating procedure for FCS for: a. SQ lineups b. WRST c. Tactical Launch	2.1 Perform power-on operations and normal procedures in the following modes: a. Tactical b. Dummy c. Twig d. Twigl e. Twog f. Twogl g. Data entry h. Standby For each condition of readiness in accordance with authorized documentation during normal operations in each condition of readiness. This instruction focuses at unfaulted tactical/CIO operational sequences of the FCS as displayed on the Fire Control Console (FCC)	3.1 <u>Equipment to Operator</u> a. Actuator/indicators b. Illumination of (a) c. Print readout d. Key actuated switch e. Thumbwheel switches f. Digital readout g. Multiposition rotary switches	4.1 <u>Equipment Simulation</u> a. Power control panel b. Fire Key Assembly c. Missile Emergency Alarm d. System Printer (PTR) e. Supervisor's Control Panel Assembly (SCPA) (1) Prime Mode Section (2) Secondary Mode (3) Status (4) Configuration (5) Console, OAG, and Printer Report (6) Missile Status (7) Station Report (8) Denote 1 and 2 (9) MTRE select (10) Launch control (11) Prepare f. Time of Day Control and Display panel g. Print readout h. Display of SCPA and print readout i. Provide for at least 4 colors on actuator/indicators j. Provide for a range of alphanumeric values	High Resolution Dynamic graphics and Pictoral Display Color or color indication
			3.2 <u>Operator to Equipment</u> a. Physical manipulation of 3.1 except 3.1 (c) b. Analysis of 3.1 (c) c. Operator coordination between components listed in 4.1	4.2 <u>Operator Interface</u> a. Provide for movable switching positions b. Provide for appropriate color and illumination c. Provide for operator input d. Provide for Weapon Officer simulation	Dynamic graphics Color or color indication Touch or Stylus response devices
			3.3 <u>Equipment to Equipment</u> a. PTR to SCPA b. Power Control Panel to SCPA c. Firing Key Assembly to SCPA d. Missile Emergency Alarm to SCPA e. TOD Control and Display panel to SPCA f. Condition of readiness and modes to SCPA g. Navigation to FCS h. Guidance (launch) (24) to FCS i. TMPS to FCS j. OAG to FCS k. MTRE MK6 & 7 to FCS l. LCG to FCS m. FC switchboard to FCS	4.3 <u>Equipment-to-Equipment Simulation</u> a. Provide for real time responses b. Provide for proper sequencing c. Ensure compatibility with documentation	Fast response time Terminal aids to authoring and editing
02 (4 hrs)	1.1 Perform all normal operating procedures without supervision and casualty procedures for all conditions of readiness with supervision	2.1 Perform all Casualty Procedures (CP's) immediate and deferred actions and all Weapon Operation Procedures (WOP's) During modes of operation (listed in 2.1, 01 level) in accordance with authorized documentation to ensure uninterrupted tactical flow. Discrimination should be stressed between indicator and operational faults.	3.1 <u>Equipment to Operator</u> a. Same as 01 level with insertion of specific casualty problems b. Status report input	4.1 <u>Equipment Simulation</u> a. Same as 01 level with insertion of specific casualty problems b. Audio reports from other areas in the FC system	Same as 01 level Simulate audio messages through text display
			3.2 <u>Operator to Equipment</u> a. Same as 01 level with insertion of specific casualty problems b. Response to 3.1 (b)	4.2 <u>Operator Interface</u> a. Same as 01 level with insertion of specific casualty problems b. Acknowledgement of 4.1 (b) and appropriate actions	Same as 01 level Keyboard
			3.3 <u>Equipment to Equipment</u> a. Same as 01 level with insertion of specific casualty problems	4.3 <u>Equipment to Equipment Simulation</u> a. Same as 01 level with insertion of specific casualty problems	Same as 01 level

Control and Display Subsystem (Continued)

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
P1 (1 hr)	1.1 Perform preventive maintenance procedures with supervision on Fire Control Console (FCC) in accordance with documentation	2.1 Perform basic preventive maintenance procedures as presented in the SMP/SOP, including operational test procedures as required by applicable documentation. This section entails only the use of the documentation on PM and operational testing procedures for representative maintenance problems.	3.1 Equipment to Operator a. Same as 02 level b. Graphics and pictorial representation of equipment and procedures	4.1 Equipment Simulation a. Demonstration of hands-on application b. Associated test equipment c. Interior components of FCC d. ITOP e. Printer	Same as 01 level
			3.2 Operator to Equipment a. Same as 02 level b. Ability to direct PM procedures and operational test procedures	4.2 Operator Interface a. Interrogation by operator of pertinent documentation and procedures	Same as 02 level
			3.3 Equipment to Equipment a. Same as 02 level b. Associated test equipment to FCC components	4.3 Equipment-to-Equipment Simulation a. Same as 02 level	Same as 02 level
C1 (1 hr)	1.1 Perform basic fault isolation and minor repair with supervision	2.1 Recognize and interpret indication of malfunctions and perform basic fault isolation procedures contained in prescribed documentation. This instruction is focused at relay and module failure	3.1 Equipment to Operator a. Same as P1 level b. Associated test equipment c. FCC components (1) Type 3 modules (2) Projection display (3) Switch display modules (4) Lamps	4.1 Equipment Simulation a. Same as P1 level b. Simulate associated test equipment panels and appropriate readings corresponding to documented parameters c. Provide for both graphic and pictorial representations of FCC components d. ITOP e. Printer	Same as 01 level
			3.2 Operator to Equipment a. Same as P1 level b. Provide for operator coordination between FCC components and associated test equipment functions	4.2 Operator Interface a. Same as P1 level b. Provide for both graphic and pictorial representations of FCC components and associated test equipment and dual display	Same as 02 level
			3.3 Equipment to Equipment a. Same as P1 level b. FCC components for associated equipment	4.3 Equipment-to-Equipment Simulation a. Same as 02 level	Same as 01 level
	1.2 Perform operational tests for basic corrective maintenance	2.2 Perform alignment, adjustment or calibration procedures and operational tests for basic corrective maintenance in accordance with documentation. The instruction at this point stresses operational testing which should not differ greatly from the basic functions provided in 2.1	3.4 Equipment to Operator a. Same as 3.1 b. FCC components	4.4 Equipment Simulation a. Same as 4.1	Same as 02 level
			3.5 Operator to Equipment a. Same as 3.2 b. Provide for operator coordination between FCC components and associated test equipment functions	4.5 Operator Interface a. Same as 4.2	Same as 02 level
			3.6 Equipment to Equipment a. Same as 3.3	4.6 Equipment-to-Equipment Simulation a. Same as 4.3	Same as 01 level
		2.3 Perform post-repair procedures in accordance with documentation	3.7 Equipment to Operator a. Same as 3.4	4.7 Equipment Simulation a. Same as 4.1	Same as 01 level
			3.8 Operator to Equipment a. Same as 3.5	4.8 Operator Interface a. Same as 4.2	Same as 02 level
			3.9 Equipment to Equipment a. Same as 3.3	4.9 Equipment-to-Equipment Simulation a. Same as 4.3	Same as 01 level
	1.3 Use test equipment required for basic corrective maintenance	2.4 Use test equipment required for basic corrective maintenance in accordance with documentation for specific repair situations	3.10 Equipment to Operator a. Same as 3.4 with insertion of specific repair problems	4.10 Equipment Simulation a. Same as 4.1	Same as 01 level
			3.11 Operator to Equipment a. Same as 3.5 with insertion of specific repair problems	4.11 Operator Interface a. Same as 4.2	Same as 02 level
			3.12 Equipment to Equipment a. Same as 3.3 with insertion of specific problems	4.12 Equipment-to-Equipment Simulation a. Same as 4.3	Same as 01 level

Test Control and Display Subsystem (TCDSS)

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
01 (1 hr)	1.1 Perform normal operating procedures for TCDSS for all tests with supervision	2.1 In missile test, fire control test, and fuze test modes, perform the following appropriate activities: a. Switch clear b. Equipment select c. Test sequence d. MSL and guidance GR test select e. Fire control GR test select f. Test (number), select and test number clear g. NSL and guidance system tests h. Fire control tests i. Printer test j. Control logic tests in accordance with authorized documentation during normal operations with supervision	3.1 <u>Equipment to Operator</u> a. Actuator/indicators b. Illumination of (a) c. Print readout	4.1 <u>Equipment Simulation</u> a. Simulate the following: (1) Test group select group (2) Test select group (3) Equipment select/status group (4) Test control/status group (5) Mode and DCC select actuator/indicator b. Simulate the following on printer (PRT) (1) Control panel (2) Print readout c. Display of ITOP and printer/PRT readout d. Provide for at least 4 colors on actuator/indicators e. Provide for a range of alphanumeric values	High Resolution, Graphics and pictorial representations High Resolution, Graphics and pictorial representations Display both panels simultaneously Color or color indication capability
			3.2 <u>Operator to Equipment</u> a. Physical manipulation of 3.1 (a) and (b) b. Analysis of 3.1 (c)	4.2 <u>Operator Interface</u> a. Provide for movable switching positions b. Provide for appropriate color and illumination c. Provide for operator input	Dynamic graphics Color or color indication capability Touch or stylus response devices
			3.3 <u>Equipment to Equipment</u> a. Printer (PRT) to ITOP b. Proper documentation c. Navigation to FCS d. Guidance (24) to FCS e. Guidance checkout facility to ITOP f. Command sequencer to FCS g. TMPS to FCS h. OAG to FCS i. DCC to FCS j. DRISS to FCS k. MCTSS to FCS l. MTRE 7 to FCS m. FC switchboard to FCS n. LCG to FCS	4.3 <u>Equipment-to-Equipment Simulation</u> a. Provide for real time responses b. Provide for proper sequencing c. Ensure compatibility with documentation	Fast response time Terminal aids to authoring and editing
02 (1 hr)	1.1 Perform all normal operating procedures without supervision and casualty procedures with supervision	2.1 Perform all normal and casualty operations on ITOP utilizing all casualty procedures (CP's) immediate and deferred actions and all weapons operations procedures (WOP's)	3.1 <u>Equipment to Operator</u> a. Same as 01 level with insertion of specific casualty problems b. Status report input	4.1 <u>Equipment Simulation</u> a. Same as 01 level b. Audio reports from relevant areas of FC system	Same as 01 level Simulate audio messages via text display
			3.2 <u>Operator to Equipment</u> a. Same as 01 level with insertion of specific casualty problems b. Response to 3.1 (b)	4.2 <u>Operator Interface</u> a. Same as 01 level b. Acknowledgement of 4.1 (b) and appropriate actions	Same as 01 level Keyboard or other response input
			3.3 <u>Equipment to Equipment</u> a. Same as 01 level with insertion of specific casualty problems	4.3 <u>Equipment-to-Equipment Simulation</u> a. Same as 01 level	Same as 01 level

Test Control and Display Subsystem (TCDSS)

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
C1 (1 hr)	1.1 Perform basic isolation and minor repair on TCDSS with supervision	2.1 Recognize and interpret indications of ITOP malfunctions by use of ITOP and PTR and perform basic fault isolation procedures in authorized documentation. This instruction is focused at module failure and entails the use of ITOP to run self-diagnostic readiness tests, print readouts of faults, and module replacement	3.1 <u>Equipment to Operator</u> a. Same as 02 level b. Type 3 modules c. Projection display units d. Switch display modules e. Lamps	4.1 <u>Equipment Simulation</u> a. Same as 02 level b. Interior ITOP components c. Module(s) placement d. Projection display units e. Lamp replacement in switch display module f. Lamp replacement in projection display module g. Insert for both graphic and pictorial representation of ITOP interior components	Same as 01 level Dynamic graphics and pictorial representations with color or color indication
			3.2 <u>Operator to Equipment</u> a. Same as 02 level b. Extraction and insertion of 3.1 (b) through (e) c. Provide for operator coordination between ITOP components, associated ITOP maintenance displays, and print readout	4.2 <u>Operator Interface</u> a. Same as 02 level b. Interrogation by operator of equipment condition and pertinent documentation and procedures	Same as 01 level
			3.3 <u>Equipment to Equipment</u> a. Same as 02 level b. Modules to ITOP c. Projection display units to ITOP d. Lamps to switch display module e. Lamps to projection display module	4.3 <u>Equipment-to-Equipment Simulation</u> a. Same as 02 level	Same as 01 level
		2.2 Perform operational/reliability tests for basic corrective maintenance in accordance with authorized documentation. This instruction is similar to those operations contained in 2.1	3.4 <u>Equipment to Operator</u> a. Same as 2.1 C1	4.4 <u>Equipment Simulation</u> a. Same as 2.1 C1	Same as 01 level
			3.5 <u>Operator to Equipment</u> a. Same as 2.1 C1	4.5 <u>Operator Interface</u> a. Same as 2.1 C1	Same as 01 level
			3.6 <u>Equipment to Equipment</u> a. Same as 2.1 C1	4.6 <u>Equipment-to-Equipment Simulation</u> a. Same as 2.1 C1	Same as 01 level

Printer Subsystem (PRTSS)

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
01 (1 hr)	1.1 Perform normal operating procedures on PRTSS in accordance with authorized documentation	2.1 Perform power-on operations and normal operating procedures in accordance with authorized documentation	3.1 <u>Equipment to Operator</u> a. Actuator/indicators b. Illumination of (a) c. Print read out	4.1 <u>Equipment Simulation</u> a. Simulate control panel b. Motor on and illumination controls c. Simulate paper moving d. Provide for at least 4 colors on actuator/indicators e. Provide for a range of alphanumeric values	High Resolution Graphic and pictoral capability Dynamic graphics Color or Color indication Programmable Symbols
			3.2 <u>Operator to Equipment</u> a. Physical manipulation of 3.1 (a) and (b) b. Analysis of (c)	4.2 <u>Operator Interface</u> a. Provide for movable switching positions (key, toggle) b. Provide for appropriate color and illumination c. Provide for operator input	Dynamic graphics Color or color indication Touch or Stylus response device
			3.3 <u>Equipment to Equipment</u> a. Power to PRT b. Paper advance to speed of paper c. Paper motion to motor on switch d. self test to print read out	4.3 <u>Equipment-to-Equipment Simulation</u> a. Provide for real/time responses b. Provide for proper sequencing c. Ensure compatibility with documentation	Fast response time Terminal aids to authoring and editing

Printer Subsystem (PTRSS) (Continued)

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
P1 (1 hr)	1.1 Perform preventive maintenance procedures with supervision on PRTSS in accordance with documentation	2.1 Perform basic preventive maintenance procedures on the printer (PTR) as presented in the SMP/SOP, including operational test procedures as required by applicable documentation. This section entails only the use of documentation on PM and operational testing procedures for representative maintenance problems.	3.1 Equipment to Operator a. Same as 01 level b. Graphics and pictorial representation of equipment and procedures	4.1 Equipment Simulation a. Demonstration of hands-on application b. Simulation of circuit breaker switches c. Associated test equipment d. Internal components of PRT	Same as 01 level
			3.2 Operator to Equipment a. Same as 01 level b. Ability to direct PM procedures and operational test equipment	4.2 Operator Interface a. Same as 01 level b. Interrogation by operator of pertinent documentation and procedures	Same as 01 level
			3.3 Equipment to Equipment a. Same as 01 level b. Power to circuit breaker switches c. Associated test equipment to PRT components	4.3 Equipment-to-Equipment Simulation a. Same as 01 level	Same as 01 level

Time of Day Subsystem (TODSS)

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
01 (1 hr)	1.1 Perform normal operations on TODSS with supervision and in accordance with authorized documentation	2.1 Perform normal operating procedures on time of day (TOD) Control and Display panel in accordance with authorized documentation	3.1 Equipment to Operator a. Multiposition rotary switches b. Keylock switch c. Pushbutton switches d. Thumbwheel switches e. Decimal indicators	4.1 Equipment Simulation a. TOD Control and Display panel b. Provide for a range of alphanumeric values c. Provide coordination between input of data and display output	High Resolution Dynamic graphics for display changes
			3.2 Operator to Equipment a. Physical manipulation of 3.1 (a) through (e)	4.2 Operator Interface a. Provide for movable switching positions b. Provide for operator input	Dynamic graphics Touch or Stylus response device
			3.3 Equipment to Equipment a. NAV to TOD Control and Display panel b. MCTSS to TOD Control Display panel	4.3 Equipment-to-Equipment Simulation a. Provide for real time responses b. Provide for proper sequencing c. Ensure compatibility with documentation	Fast response time Terminal aids for authoring and editing

Digital Control Computer (DCC)

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
01 (1 hr)	1.1 Perform normal operating procedures for DCC with supervision	2.1 Perform the following procedures on DCC a. STOP-STEP b. MASTER CLEAR c. BOOT STRAP in accordance with authorized documentation by positioning DCC actuator/indicators (A/I's) CMSS panel A/I's in the proper normal operating modes with supervision	3.1 Equipment to Operator a. Actuator/Indicators b. Illumination of (a)	4.1 Equipment Simulation a. Simulate the following panels: (1) BPSS Panel (2) CMSS Panel (3) KBDSS Display b. Provide for at least 4 colors on actuator/indicators c. Provide for a range of alphanumeric values	High Resolution, Display of several panels simultaneously, Graphics (dynamic) and pictorial representation Color or color indication capability Programmable symbols, fast response
			3.2 Operator to Equipment a. Physical manipulation of 3.1 b. Provide for operator coordination between DCC and associated panels	4.2 Operator Interface a. Provide for movable switching positions b. Provide for appropriate color and illumination c. Provide for operator input	Dynamic graphics Color or color indication Touch or Stylus response device
			3.3 Equipment to Equipment a. BPSS to DCC b. CMSS to DCC c. KBDSS to DCC	4.3 Equipment-to-Equipment Simulation a. Provide for real time responses b. Provide for proper sequencing c. Ensure compatibility with documentation	Fast response time Authoring aids at terminal for editing and checkout

DDC Computer Programs

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
01 (2 hrs)	1.1 Perform boot straping on all available types of DCC computer programs in normal operations in accordance with authorized documentation with supervision	2.1 Perform boot straping operations on all available types of DCC computer programs by use of BPSS, CMSS, COISS, MTPSS, KBDSS, ITOP, and PRTSS in accordance with authorized documentation. Performance be based on correct positioning and and sequencing prescribed in normal operating modes with supervision	3.1 Equipment to Operators a. Actuator/Indicators b. Illumination of (a) c. Switches d. Printer Readouts e. Coordination Effects	4.1 Equipment Simulation a. Simulate the following: (1) BPSS Panel (2) CMSS Panel (3) COISS Panel (4) MTPSS Input (5) ITOP (6) Printer (7) Keyboard b. Provide for at least 4 colors on actuators/indicators c. Provide for range of alphanumeric values	High Resolution, Dynamic graphics, Pictoral representation Color or color indication capability
			3.2 Operator to Equipment a. Physical manipulation of 3.1 b. Provide for operator coordination between associated equipment c. Analysis of 3.1 (d)	4.2 Operator Interface a. Provide for movable switching positions b. Provide for appropriate color and illumination c. Provide for operator input	Dynamic Graphics Color or color indication capability Touch or Stylus response
			3.3 Equipment to Equipment a. BPSS to DCC b. CMSS to DCC c. COISS to DCC d. MDFSS to DCC e. ITOP to DCC f. PRTSS to DCC g. KBDSS to DCC	4.3 Equipment-to-Equipment Simulation a. Provide for real time responses b. Provide for proper sequencing c. Ensure compatibility with documentation	Fast response time Terminal aids to authoring and editing

DCC Computer Program (Continued)

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
02 (4 hrs)	1.1 Perform all normal operations without supervision and casualty procedures with supervision	2.1 Perform appropriate immediate and deferred action on casualties in accordance with authorized documentation	3.1 Equipment to Operator a. Same as 01 level with insertion of specific casualty problems	4.1 Equipment Simulations a. Same as 01 level with insertion of specific casualty problems	Same as 01 level
			3.2 Operator to Equipment a. Same as 01 level with insertion of specific casualty problems	4.2 Operator Interface a. Same as 01 level with insertion of specific casualty problems	Same as 01 level
			3.3 Equipment to Equipment a. Same as 01 level with insertion of specific casualty problems	4.3 Equipment-to-Equipment Simulation a. Same as 01 level with insertion of specific casualty problems	Same as 01 level
I1 (1 hr)	1.1 Perform operational tests for basic corrective maintenance in accordance with authorized documentation with supervision	2.1 Perform operational tests for basic corrective maintenance on all available types of DCC computer programs by use of CMSS, KBDSS and PRTSS in accordance with authorized documentation	3.1 Equipment to Operator a. Same as 01 level	4.1 Equipment Simulation a. Same as 01 level minus irrelevant equipment	Same as 01 level
			3.2 Operator to Equipment a. Same as 01 level	4.2 Operator Interface a. Same as 01 level	Same as 01 level
			3.3 Equipment to Equipment a. CMSS to DCC b. KBDSS to DCC c. PRTSS to DCC d. Proper maintenance computer programs to DCC	4.3 Equipment-to-Equipment Simulation a. Same as 01 level	Same as 01 level
		2.2 Recognize and interpret indications of malfunctions in accordance with authorized documentation	3.4 Equipment to Operator a. Same as 3.1 with insertion of specific fault isolation programs	4.4 Equipment Simulation a. Same as 4.1	Same as 01 level
			3.5 Operator to Equipment a. Same as 3.2	4.5 Operator Interface a. Same as 4.2	Same as 01 level
			3.6 Equipment to Equipment a. Same as 3.3 with insertion of specific fault isolation documentation	4.6 Equipment-to-Equipment Simulation a. Same as 4.3	Same as 01 level

Basic Processor Subsystem (BPSS)

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
P1 a (1 hr)	1.1 Perform preventative maintenance procedures on BPSS in accordance with documentation	2.1 Perform basic preventative maintenance procedures as presented in the SMD/SOP, including operational and reliability tests of DCC as required by authorized documentation. This section entails only the use of the documentation on PM and operational and reliability procedures for representative maintenance problems	3.1 <u>Equipment to Operator</u> a. Same as ITOP b. Same as COISS c. Same as CMSS d. Same as PRTSS e. Same as KBDSS f. Coordination effect	4.1 <u>Equipment Simulation</u> a. Simulate the following: (1) ITOP (2) System PRTSS (3) COISS (4) CMSS (5) KBDSS b. Dual display for coordination effect	High Resolution, Dynamic Graphics and pictorial display Represent two panels at once through dual or split screen
			3.2 <u>Operator to Equipment</u> a. Physical manipulation of 3.1 b. Ability to direct PM procedures and operational/reliability test procedures	4.2 <u>Operator Interface</u> a. Interogation by operator of equipment condition and pertinent documentation and procedures	Keyboard or other response device
			3.3 <u>Equipment to Equipment</u> a. ITOP to BPSS b. COISS to BPSS c. CMSS to BPSS d. PRTSS to BPSS e. KBDSS to BPSS	4.3 <u>Equipment-to-Equipment Simulation</u> a. Provide for real time responses b. Provide for proper sequencing c. Ensure compatibility with documentation	Fast response time Terminal aids to authoring and editing
C1 b (2 hrs)	1.1 Perform basic fault isolation and minor repair on BPSS with supervision	2.1 Recognize and interpret indications of malfunction by use of ITOP and PRTSS and perform basic fault isolation procedures contained in authorized documentation. This instruction is focused at primarily module failure and entails the use of the CMSS to run readiness tests, printouts of faults performing maintenance bootstrap procedures, running MTFSS and MTFSS routines error dictionary interface and module replacement.	3.1 <u>Equipment to Operator</u> a. Same as P1 level b. Tape slot c. Tape cartridge d. Type 3 module	4.1 <u>Equipment Simulation</u> a. Same as P1 level b. Simulate the following: (1) MTFSS (2) Tape cartridge (3) Type 3 module (4) Interior arrangement of BPSS components c. Provide for both graphic and pictorial presentation of BPSS interior components	Same as P1 level Color or color indication capability, graphics pictorial representation
			3.2 <u>Operator to Equipment</u> a. Same as P1 level b. Insertion of (c) into (b) c. Extraction and insertion of (d) d. Provide for operator coordination between BPSS components and associated maintenance tests with CMSS	4.2 <u>Operator Interface</u> a. Same as P1 level	Same as P1 level
			3.3 <u>Equipment to Equipment</u> a. Same as P1 level b. Cartridge to proper MTFSS programs c. PTRSS to error	4.3 <u>Equipment-to-Equipment Simulation</u> a. Same as P1 level	Same as P1 level
		2.2 Perform operational/reliability tests for basic corrective maintenance in accordance with documentation. This is similar to those operations contained in 2.1	3.4 <u>Equipment to Operator</u> a. Same as 2.1 C1	4.4 <u>Equipment Simulation</u> a. Same as 2.1 C1	Same as P1 level
			3.5 <u>Operator to Equipment</u> a. Same as 2.1 C1	4.5 <u>Operator Interface</u> a. Same as 2.1 C1	Same as P1 level
			3.6 <u>Equipment to Equipment</u> a. Same as 2.1 C1	4.6 <u>Equipment-to-Equipment Simulation</u> a. Same as 2.1 C1	Same as P1 level

Data Communications Processor Subsystem (DCPSS)

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
P1 (1 hr)	1.1 Perform preventative maintenance procedures on DCPSS in accordance with documentation	2.1 Perform basic preventative maintenance procedures as presented in the SMP/SOP, including operational tests and diagnostic programs as required by authorized documentation. This section entails only the use of the documentation on PM and operational and reliability procedures for representative maintenance problems.	3.1 Equipment to Operator a. Same as BPSS b. Same as CMSS c. Same as COISS d. Same as KBDSS e. Same as PTRSS f. Coordination effect	4.1 Equipment Simulation a. Simulate the following: 1. CMSS 2. COISS 3. KBDSS 4. System PTRSS b. Dual display for coordination effect	High Resolution Dynamic graphics and pictoral display Represent two panels at once through dual or split screen
			3.2 Operator to Equipment a. Physical manipulation of 3.1 b. Ability to direct PM procedures and operational test procedures	4.2 Operator Interface a. Interrogation by operator of equipment condition and pertinent documentation and procedures	Keyboard or other response device
			3.3 Equipment to Equipment a. BPSS to DCPSS b. CMSS to DCPSS c. COISS to DCPSS d. PTRSS to DCPSS e. MTFSS to DCPSS f. MDFSS to DCPSS	4.3 Equipment-to-Equipment Simulation a. Provide for real time responses b. Provide for proper sequencing c. Ensure compatibility with documentation	Fast response time Terminal aid to authoring and editing
C1 (1 hr)	1.1 Perform basic fault isolation and minor repair on DCPSS with supervision	2.1 Recognize and interpret indications of malfunction and perform basic fault isolation procedures contained in authorized documentation.	3.1 Equipment to Operator a. Same as P1 level	4.1 Equipment Simulation a. Same as P1 level b. Provide for both graphic and pictorial presentation of MXU and CIU components.	Same as P1 level
			3.2 Operator to Equipment a. Same as P1 level b. Ability to direct operational test procedures and diagnostic programs	4.2 Operator Interface a. Same as P1 level	Same as P1 level
			3.3 Equipment to Equipment a. Same as P1 level	4.3 Equipment-to-Equipment Simulation a. Same as P1 level	Same as P1 level

Keyboard and Display Subsystem (KBDSS)

O1 (1 hr)	1.1 Perform normal operating procedures for KBDSS with supervision	2.1 Perform the following normal operations a. Selection of DCC b. COISS interface c. DCC computer program interface d. Entry of appropriate data e. Extraction of appropriate data in accordance with authorized documentation with supervision	3.1 Equipment to Operator a. Actuator/indicators b. Illumination of (a) c. Function switches d. DCC select toggle switches e. Numerical, decimal, algebraic sign keys f. Plasma display g. Light-emitting diode (LED) h. 2 brightness differential i. Visual cursor	4.1 Equipment Simulation a. Simulate the following: (1) Display panel (2) Keyboard assembly b. Provide for 8 lines of 32 characters per line c. Display 64 different characters d. Provide for at least 4 colors on actuator/indicators e. Provide for range of alphanumeric values f. Provide for command, data, and interrupt word format(s)	High Resolution, Dynamic Graphics and pictorial representation Full character set Color or color indication
			3.2 Operator to Equipment a. Physical manipulation of (a) through (e) and (i)	4.2 Operator Interface a. Provide for moveable switching positions b. Provide for appropriate color and illumination c. Provide for operator input	Dynamic Graphics Color or color indication Touch or Stylus response device
			3.3 Equipment to Equipment a. DCC computer programs to KBDSS	4.3 Equipment-to-Equipment Simulation a. Provide for real/time responses b. Provide for proper sequencing c. Ensure compatibility with documentation d. Provide keyboard to cursor coordination	Fast Response Time Terminal aids to authoring and editing

Computer Operatory Interface Subsystem (COISS)

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
01 (1 hr)	1.1 Perform normal operating procedures with supervision	2.1 Perform basic operation on CMSS and use CMSS to perform basic interface operations with DCC and selection of DCC in accordance with authorized documentation	3.1 <u>Equipment to Operator</u> a. Actuator/indicators b. Illumination of (a) c. Key actuated switch	4.1 <u>Equipment Simulation</u> a. Two sections of operator panel b. Provide for at least 4 colors on actuator/indicators c. Provide for range of alphanumeric values	High Resolution, Dynamic graphics and pictoral representation Color or color indicators
			3.2 <u>Operator to Equipment</u> a. Physical manipulation of 3.1	4.2 <u>Operator Interface</u> a. Provide for movable switching positions b. Provide for appropriate color and illumination c. Provide for operator input	Dynamic graphics Color Touch or Stylus response device
			3.3 <u>Equipment to Equipment</u> a. DCC to COISS b. DCPSS to COISS c. CDSS to COISS d. MDFSS to COISS	4.3 <u>Equipment-to-Equipment Simulation</u> a. Provide for real time responses b. Provide for proper sequencing c. Ensure compatibility with documentation	Fast response time Terminal aids to authoring and editing

Computer Maintenance Subsystem (CMSS)

TRAINING LEVEL	ACTION ITEMS (TOS's)	INSTRUCTION DESCRIPTION	SIMULATION REQUIREMENTS	POSSIBLE CBI STRATEGY(S)	TERMINAL ITEMS
01 (1 hr)	1.1 Perform normal operating procedures for CMSS with supervision	2.1 Perform all normal operations by use of self-test, bootstrap, status, unit select, program status, word, keyboard, and plasma displays in accordance with authorized documentation for proper insertion, and sequencing	3.1 <u>Equipment to Operator</u> a. Actuator/indicators b. Illumination of (a) c. Push buttons for alphanumeric insert d. Plasma display	4.1 <u>Equipment Simulation</u> a. Simulate the following: (1) Self-test (2) Control (3) Status (4) Unit select - auto test - maint mode extended (5) Display select (6) Keyboard (7) Program status word (insert (b) and (d) from DCC)	High Resolution, Graphic or Pictorial Representation
			3.2 <u>Operator to Equipment</u> a. Physical manipulation of 3.1 b. Analysis of (d)	4.2 <u>Operator Interfaces</u> a. Provide for movable switching positions b. Provide for appropriate color and illumination c. Provide for operator input	Dynamic Graphics Color or Color Indication Capability Touch or Stylus response device
			3.3 <u>Equipment to Equipment</u> a. DCC computer programs to CMSS b. MTFSS to CMSS c. KBDSS to CMSS	4.3 <u>Equipment-to-Equipment Simulation</u> a. Provide for real time responses b. Provide for proper sequencing c. Ensure compatibility with documentation	Fast Response Time Terminal Aids to authoring and editing

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